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THE CARNEGIE MUSEUM.*

By W. J. HOLLAND, LL. D.,
DIRECTOR OF THE MUSEUM.

IT was a glorious summer day. The sunlight gleamed through the trees, which covered the mountain-top. Checkers of light and shade wove themselves upon the fern-clad soil. Seated upon the trunk of a fallen tree the man whose name to-day is borne by scores of institutions, which his more than princely benevolence has founded, talked to a friend in relation to his plans for the great city, the history of the growth of which is closely linked with the story of his own wonderful career. "The Allegheny Library will before long be nearing completion," he said, "and the time is approaching to execute my designs for Pittsburgh. In my original offer I agreed to give Pittsburgh a quarter of a million of dollars with which to build a library, but I mean to enlarge my gift, and make it a million. I have given Allegheny a library and a music-hall. I wish to do as much for Pittsburgh. The library idea is central. My convictions on that subject are established. But I wish to do something more than to found a library in Pittsburgh. I am thinking of incorporating with the plan for a library that of an art-gallery in which shall be preserved a record of the progress and development of pictorial art in America, and perhaps also of making some provision for advancing knowledge among the people through the addition of accommodations for the various societies which in recent years have struggled into existence among us. These societies deserve to be encouraged. I mean the Art Society, the Botanical Society of Western Pennsylvania, the Microscopical Society of Pittsburgh, and

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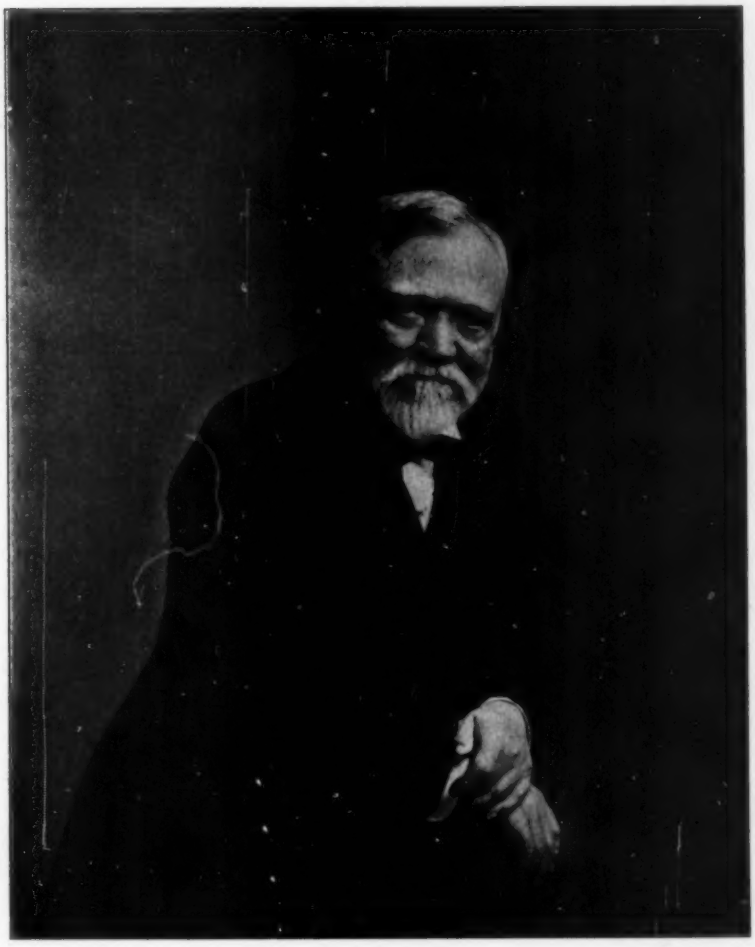
all those other societies. Get them to join their forces and unite to form one society—call it the Academy of Science and Art of Pittsburgh, if you please—and I will furnish accommodations for them when I come to build the library in Pittsburgh. We can treat with one central organization better than with half a dozen different societies. Some of these societies are forming collections of books, historical objects, natural history specimens. These things ought to be kept in fire-proof quarters. That is another point on which I am sound. I believe in fire-proof construction. There are your butterflies, for instance. Such collections should not be exposed to the risk of fire. When I build the library I will provide a good place in which to keep them." So the plan was unfolded and its outlines sketched while the leaves rustled and the birds sang overhead.

Nine years took their flight, and at last the dream was transmuted into stone and marble. The structure which the fancy had outlined stood revealed in the beauty of architectural form and the still greater beauty of definite purpose and usefulness. When on November 5, 1895, the edifice was formally presented to the city of Pittsburgh by its donor it was found to contain accommodations for a great central library, with provision for the administration from this center of a number of branch libraries, for the erection of which ample funds had been provided. Under the same roof was a music-hall, one of the most perfect of its kind in the United States, an art gallery of noble proportions and, forming the southern wing of the great building, the Museum, on the first floor of which was provided a spacious lecture-hall adapted to the uses of the learned societies, which, in pursuance of the suggestion of the founder, had been merged into the Academy of Science and Art of Pittsburgh.

Prior to the opening of the building arrangements were made by the Academy of Science and Art to gather together a collection of objects suitable for exhibition in a museum. The Curator of the Academy, Dr. Gustave Guttenberg, labored strenuously to place the material in proper order, and was aided by his associates, who freely gave their time and generously contributed of their means to make the exhibition worthy of the occasion. The result revealed, as all such attempts in our great cities are certain to show, how large an accumulation of really choice specimens exists in the hands of individuals who are possessed of artistic and scientific tastes. Ethnological, mineralogical and zoological collections of no small merit were rapidly brought together from the homes of scores of citizens, whose interest had been awakened, and the collections in the possession of the Western University of Pennsylvania were laid under heavy contribution to fill up any gaps, which required for the time being to be closed, in order to replenish the cases and dress the halls.

When, on November 5, 1895, the edifice was thrown open to the people, the splendid generosity of the gift produced a profound impression, but the gratitude which was felt was converted into amazed thankfulness when the donor announced to the large audience which filled the auditorium that it was his intention to supplement his gift by the



ANDREW CARNEGIE.

bestowal of an additional million of dollars as a permanent endowment, the annual income to be used in promoting the interests of the Art Gallery and the Museum. The custodianship of the endowment fund was committed to a Board of Trustees, consisting of the gentlemen who were already vested with the care of the building, and eighteen others, who were named by the donor because of their interest in those things

which tend to promote scientific and æsthetic culture. The formal title assumed by this body was 'The Board of Trustees of the Carnegie Fine Arts and Museum Collection Fund,' subsequently changed to 'The Trustees of the Carnegie Institute.'

The announcement of this gift and the conditions which were to govern the trust necessitated a change in the administration of the affairs of the Museum. The control of the Museum and the collections contained in it was transferred from the Academy of Science and Art to the newly appointed Trustees of the Endowment Fund, the Academy of Science and Art engaging to cooperate with the Trustees and to apply the revenues in their possession, derived from the annual dues of the membership, to the maintenance of courses of popular lectures in the hall of the Museum.

GUSTAVE GUTTENBERG.

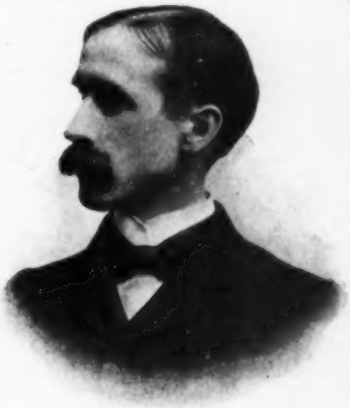
The immediate oversight of the Museum was vested by the action of the Trustees in a committee of eight, including *ex officio* the President of the Board. The committee as at first constituted consisted of the following gentlemen: C. C. Mellor, Chairman; Samuel Harden Church, Litt. D., Secretary; W. N. Frew, Esq., President of the Board; Rev. A. A. Lambing, President of the Western Pennsylvania Historical Society; Hon. H. P. Ford, Mayor of Pittsburgh; John A. Brashear, Sc. D.; Josiah Cohen, Esq., and W. J. Holland, LL. D., Chancellor of the Western University of Pennsylvania.

Unfortunately, the hand of death removed the man who would have been the first choice of the Trustees for the important position of Director of the new Museum. Professor Gustave Guttenberg died in

Vienna before a full organization of the committee on the affairs of the Museum had been effected. The first act of the Board was to purchase from his widow the beautiful collection of minerals which he had made, and which had been one of the attractive features of the opening exhibition of the Museum.

W. N. Frew, President of the Board of Trustees.

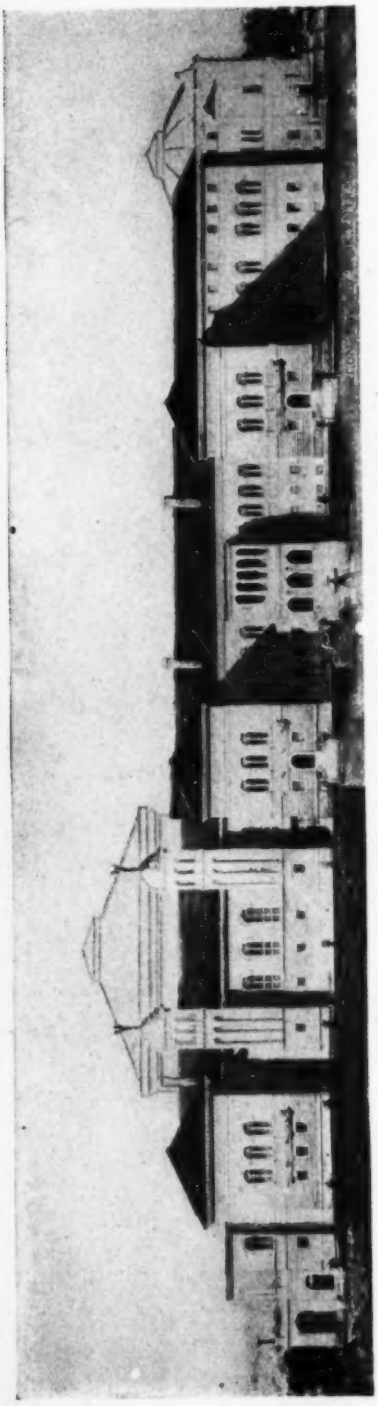
C. C. Mellor, A.M., Chairman of the Committee on the Museum.



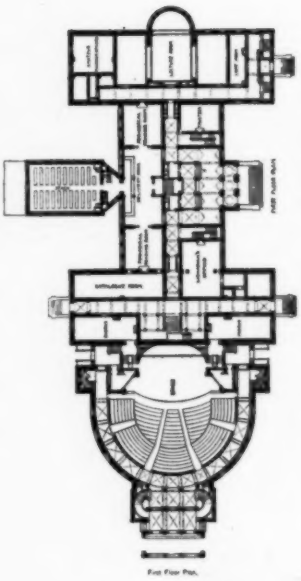
S. H. Church, Litt. D., Secretary of the Board of Trustees.

After several experiments in administrative arrangement, which were not wholly satisfactory, in the spring of 1898 Dr. W. J. Holland was elected as the Director of the Museum. This relationship still continues.

The Museum at present occupies six halls, which are devoted to

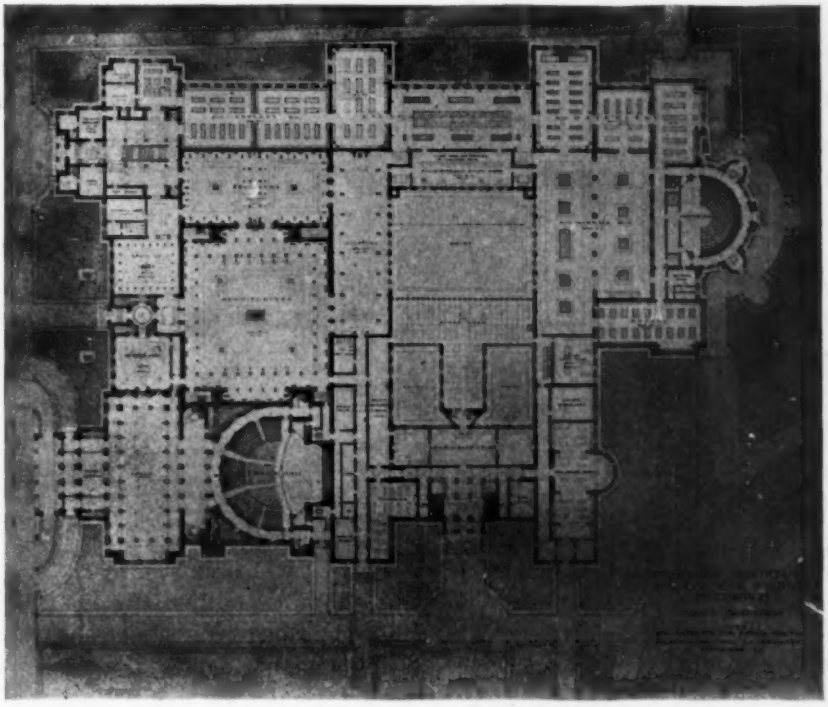


SIDE ELEVATION OF THE PROPOSED NEW BUILDINGS OF THE CARNEGIE INSTITUTE.



GROUND PLAN OF THE PRESENT CARNEGIE INSTITUTE.

purposes of display, and seven rooms which are used as laboratories and offices. Three of the exhibition halls are situated on the second floor of the building and three upon the third. Two of the laboratories are situated on either side of the lecture-hall on the first floor, and the three remaining laboratories are in the basement of the building. The floor space available for the display of the collections amounts, at the present time, to a little more than twelve thousand square feet. The floor space devoted to laboratories is five thousand square feet. The lecture-hall will comfortably accommodate about six hundred persons.



GROUND PLAN OF THE PROPOSED ADDITION TO THE CARNEGIE INSTITUTE.

The walls of a museum are to its contents what the frame is to a picture. The generosity of the founder provided at the outset a beautiful edifice under the roof of which to assemble the collections which it was destined to contain, but he did not forget to provide for what after all is the museum itself, and has from year to year supplemented the income derived from his original gift of a million of dollars by the purchase of collections, which he has himself selected, or by placing at the disposal of the Director of the Museum funds with which to make special collections.

The growth of the Museum and the related departments of the Institute has been so rapid, and the usefulness and popularity of the entire undertaking has been so great, that the founder has found himself constrained to again provide for further enlargement, and in the fall of the year 1899 and the spring of 1900 preliminary plans for extension were prepared, which subsequently were approved by Mr. Carnegie. These plans contemplate the ultimate expenditure of $3,600,000, in new construction, greatly enlarging and perfecting the facilities of the Museum, the Library and the Art Gallery. When these plans are executed the city of Pittsburgh will have an institution second in its importance to no other of like character in the New World, and surpassing many of the famous institutions of Europe in the provision made within its walls for promoting a knowledge of literature, science and art.

Inasmuch as Pittsburgh is located in the very heart of the Appalachian region, it was in the beginning determined among other things to make the collections acquired by the institution as thoroughly illustrative of this region as possible. Accordingly much effort has been expended in endeavoring to obtain specimens illustrating the geology, the mineral resources, and the flora and fauna of the region of which Pittsburgh may be said to be the metropolis. By the gift of the large herbarium of the Western Pennsylvania Botanical Society, to which extensive additions have been made, the flora of the region is already well represented. The fauna is also represented by collections which are extensive and rapidly growing. Almost all the mammals and birds known to exist in Western Pennsylvania are contained in the collection, and through the diligence of those in charge of the department of ornithology several species not heretofore known to occur within the limits of Pennsylvania have been added to the faunal list. The collections representing the insect life of the region are great. Extensive research is going on in every direction, and it is hoped ultimately to amass and bring together representatives of every form of life, whether animal or vegetable, known to occur in the upper valley of the Ohio. Collectors have been sent out who have extended their labors over the whole western half of the State, from Erie to the southern boundary, and westward into eastern Ohio, and southward into West Virginia. It no doubt will require many years finally to complete the biological survey of this extensive region, but a very satisfactory beginning has already been made. Side by side with the work done in the department of biology much work has been done in gathering together ethnological and historical material, the former throwing light upon the aboriginal inhabitants of the territory, the latter serving to illustrate its development since occupied by civilized man. The industries of the region likewise have claimed

attention, and important industrial exhibits have been formed, showing the development of commerce and manufactures in western Pennsylvania.

It is far, however, from the purpose of the Trustees to restrict the Museum to the work which has just been outlined. The whole field of research is before them, and already very large accumulations of material from distant parts of our own continent and from foreign lands have been brought together. The collections already in the possession of the Museum may be approximately classified as follows:

	Species and Varieties.	Specimens.
Minerals	400	4,000
Geological Specimens		1,000
Botany (recent species)	17,000	100,000
Botany (fossil)	150	1,200
Paleontology (invertebrate)	500	2,400
Paleontology (vertebrate)	160	3,500
Porifera, Echinoderms, etc	500	1,250
Mollusca	9,500	100,000
Crustacea	100	2,000
Arachnida	300	1,200
Myriapoda	50	1,200
Hymenoptera	1,250	4,000
Lepidoptera	20,000	300,000
Diptera	1,000	5,000
Coleoptera	20,000	275,000
Hemiptera	750	4,000
Orthoptera	400	1,600
Neuroptera	300	1,200
Fishes	500	1,800
Reptilia and Batrachia	150	1,750
Birds	1,200	9,000
Mammals	300	1,050
Total	74,510	822,150

The foregoing table shows that the collections representing the various classes in the vegetable and animal kingdom are somewhat unequal in the matter of extent. The assemblage of shells is already large because of the acquisition by the Museum of several considerable collections, one of them made in South America by Mr. Herbert H. Smith; the other by the late F. R. Holland, which contains a large number of species represented by cotypes and specimens autographically labeled by Adams, Anthony, Bland and other early American conchologists. This collection at the time of its acquisition by the Carnegie Museum contained over six thousand species and is especially rich in West Indian terrestrial mollusca. The collection of Lepidoptera is also exceedingly rich in species, as well as specimens, containing as it does, the entire collection of Mr. W. H. Edwards, the author of the 'Butterflies

of North America,' with almost all his types, as well as many types and paratypes obtained from Boisduval, Tryon, Reakirt, Henry Edwards, S. H. Scudder, and Dr. Herman Behr. The collection also includes the entire collection made by Theodore L. Mead, the types of all species described by the present Director of the Museum, numerous types of species described by Lord Walsingham, E. L. Ragonot, Arthur G. Butler, Sir George Hampson, William Doherty, Dr. Henry Skinner and others, and cotypes of a multitude of species obtained from various authors in different parts of the world. There are over three thousand types and cotypes in the collection of Lepidoptera. The collection is particularly rich in North American, Japanese, Indian and African species. The Knyvett collection of Indian Lepidoptera was purchased

HENRY ULKE.

FREDERICK S. WEBSTER.

by Mr. Carnegie some years ago. It contains over three thousand species of Indian Lepidoptera, mostly represented by large series of specimens. Large portions of the collections made by Doherty in India and in the Malay Archipelago are also here. The micro-lepidoptera of Japan, collected by the late Henry Pryer, of Yokohama, are also incorporated in the collection, having been purchased in 1887, a year before the lamented death of Pryer. Latterly extensive additions have been made in the form of material secured from various localities in Africa, Mexico and Central America, and from the continent of South America, the latter principally through the labors of Herbert H. Smith.

The assemblage of coleoptera, comprising among other things the collections of the late Dr. Hamilton, of Allegheny, and of Henry

Ulke, of Washington, D. C., is one of the largest and most perfect collections of the beetles of North America in existence. It is rich in types and cotypes, several thousand species being thus represented. In addition to the North American collections of coleoptera, there are vast accumulations of material from other parts of the world, especially from Africa, tropical America and Japan. The collections in other orders of insects represent mostly North American material, though in every order there is more or less exotic material.

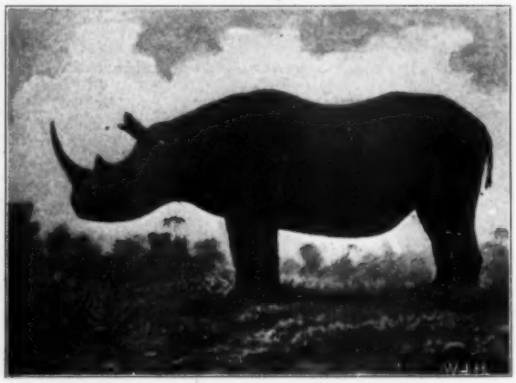
In the ornithological collections North American species preponderate. There are about nine thousand specimens of birds in the pos-

A PEEP INTO THE TAXIDERMIC LABORATORY.

session of the Museum, as the result of the accumulations made during the last three years. Fully three-fourths of these belong to the native series. Of the species of birds known to occur within the State of Pennsylvania almost all are represented. Great skill and taste have been displayed by Mr. Frederick S. Webster, the chief preparator in the department of zoology, in the composition of a number of very life-like and attractive groups representing some of the more remarkable as well as the commoner forms of bird-life found in America. The groups of flamingoes, Californian condors and brown pelicans are large and effective. One of the most striking compositions is that of the famous setter-dog, 'Count Noble,' flushing a covey of quails. 'Count Noble,'

the progenitor of many of the finest dogs of his race in America, breathed his last in Pittsburgh, and by happy fortune his skin was preserved and came into the possession of the Museum. Many of the smaller groups of birds delineate accurately the habits of the more familiar species and are accepted as masterpieces of the taxidermic art.

The mammals are represented by small, but important, collections. One of the recent acquisitions is that of a specimen of *Rhinoceros simus*. This large mammal, which is, with the exception of the elephant, the largest of terrestrial quadrupeds, is believed to be on the verge of extinction. A few years ago the Hon. Cecil Rhodes secured a specimen by purchase, which he presented to the South African Museum at Cape Town. Another was secured by the British Museum, a third specimen was acquired by the Hon. Walter Rothschild for his private collection at Tring, and a fourth was purchased by the Imperial Academy of Sci-



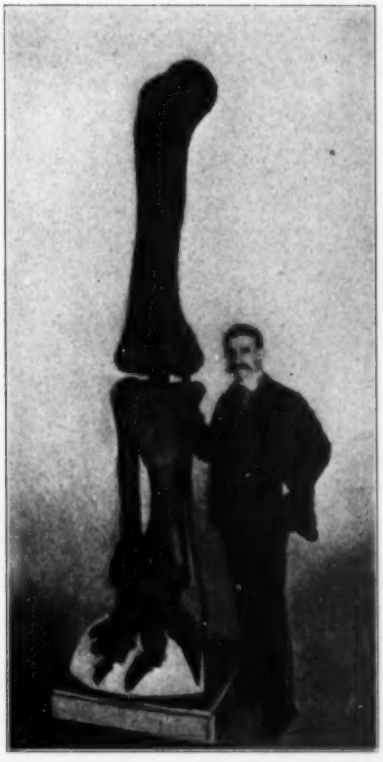
RHINOCEROS SIMUS BURCHELL.

ences at St. Petersburg. The specimen just acquired by the Carnegie Museum is the fifth to be preserved as a memorial of its rapidly vanishing race, and is the only specimen known to exist in the New World.

One of the most fruitful departments of activity in connection with the Museum is presided over by Prof. J. B. Hatcher, the famous explorer and paleontologist. Mr. Carnegie has long realized the importance of paleontology as throwing light upon the evolution of species, and in the spring of 1899 provided a special fund for research in this direction. The results have been most satisfactory, when regard is had alike to the number of the important discoveries which have been made and the beauty and perfection of the specimens which have been obtained. It is well known that the evolution of the horse took place in North America. The discoveries of Professor Hatcher made in 1900 show that in all probability in like manner the rhinoceros was

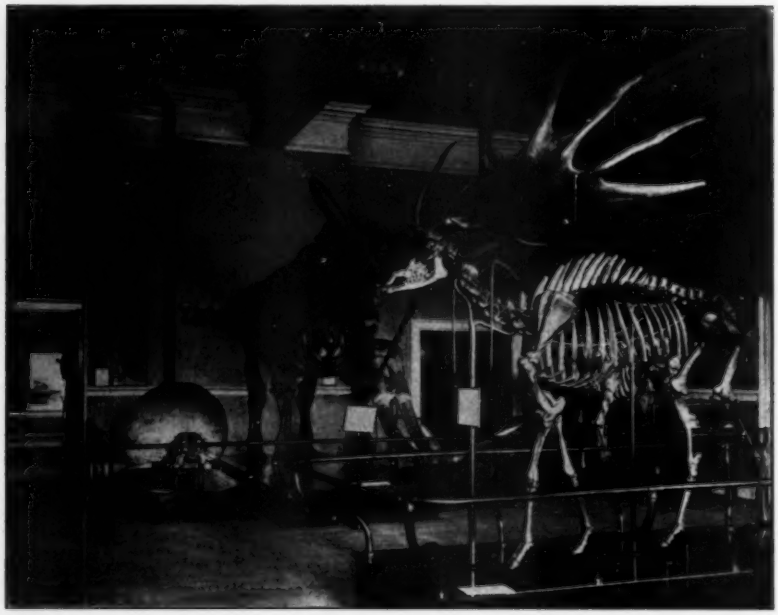
evolved from a primitive form upon the same theater of zoogenic energy. The most striking objects in the paleontological section, from a popular standpoint, are the huge dinosaurs from the Jurassic beds of Wyoming and Colorado. The most perfect specimen of *Diplodocus longus* Marsh known to exist anywhere was secured in the summer of 1899. This huge, lizard-like quadruped was about seventy feet in length from the tip of the nose to the end of the tail, and stood fully fifteen feet in height at the hips. Six skeletons of Brontosaurus, a still huger mon-

GORILLA, SPECIMEN COLLECTED BY REV. A. C. GOOD, PH. D., AT KANGWE, OGOVE RIVER, WEST AFRICA.



IN THE PALEONTOLOGICAL LABORATORY: SETTING UP THE HIND LEG OF A BRONTOSAUR.

ster, have also been discovered and collected. In no instance were these skeletons complete, but enough material has been secured, it is believed, to admit of the restoration of a composite skeleton of Brontosaurus as well as that of Diplodocus. Within the limits of a brief sketch it is impossible to speak at length of the collections brought together in the section of paleontology, but it is worthy of note that the Museum contains the largest specimen of the Mastodon known to exist, and with the single exception of the 'Warren Mastodon,' which



A Corner in the Hall of Paleontology.

A Glimpse into the Hall of Ethnology. North American Indians.

is now hidden away in Boston and invisible to the public, probably the most perfect specimen in any Museum.

A good foundation has been laid for the development of the section of archeology. The aboriginal races of America as represented by the mound-builders of the Ohio Valley, the cliff-dwellers of Arizona and the ancient populations of Mexico are in evidence in many ways. One of the latest acquisitions has been a series of reproductions of the carvings in stone preserved in the National Museum of Mexico. These

THE MOKI SNAKE DANCERS. GROUP MODELED BY T. A. MILLS.

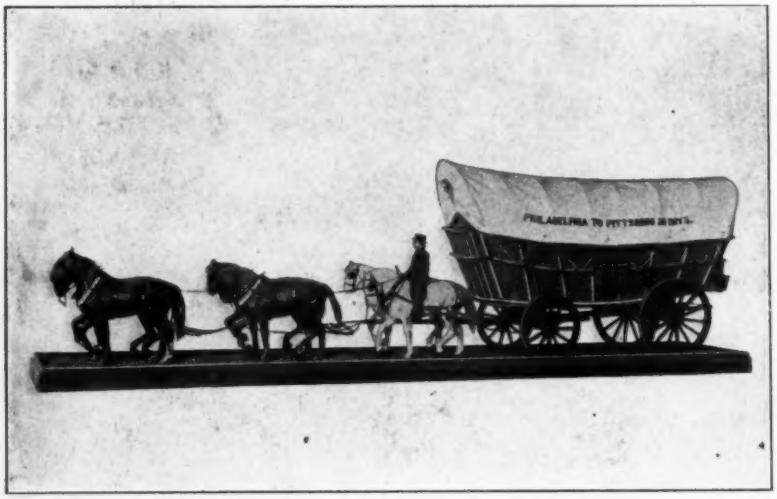
reproductions were made at the expense of Mr. Carnegie and are a duplication to the city of Pittsburgh of the gift made recently to the city of New York by the Duc de Loubat, and preserved in the American Museum of Natural History in Central Park.

The surviving Indian races of North America are represented by an extensive series of models and groups made by Mr. T. A. Mills, the well-known sculptor, all being clothed in characteristic costumes, selected with great care to represent the manners and customs which prevail among them. Besides, there are extensive collections of imple-

ments and utensils in use among these various tribes. The same remark holds good of the Esquimaux of Alaska.

The archeology of the old world has not been forgotten, and already, partly by gift and partly by purchase, considerable assemblages of specimens throwing light upon the ancient civilizations of southern Europe, Egypt and Asia Minor have been secured. The collection of reproductions of the famous Neapolitan bronzes, presented by Mr. Carnegie, duplicates for Pittsburgh the same series now in the Metropolitan Museum of Art in New York. The collections annually obtained through the Pittsburgh Branch of the Egypt Exploration Fund constitute an ever-growing series of high valuable and important objects.

The development of the domestic and industrial arts in America from the first colonization to the present is illustrated by a series of

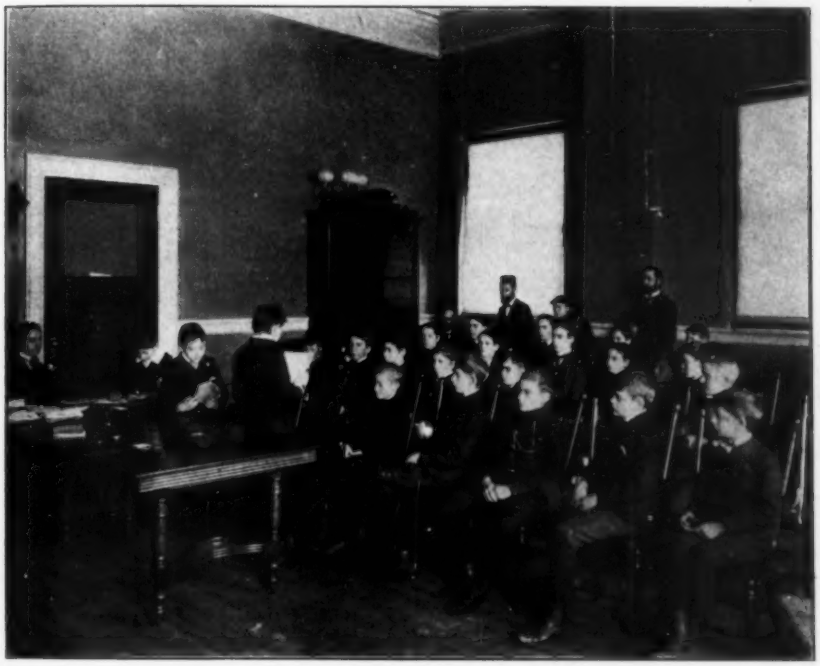


MODEL OF CONESTOGA WAGON, MADE BY WILSON BANKS AND T. A. MILLS.

collections to which additions are being rapidly made. The evolution of methods of transportation is shown by a long series of models constructed by Mr. Wilson Banks, Mr. T. A. Mills and others. This series is in part a reduplication of specimens now in the U. S. National Museum at Washington.

The end for which museums exist is not simply the acquisition and preservation of curious and instructive specimens. The great object which such an institution should ever keep in view is the diffusion of knowledge. The management of the Carnegie Museum has realized this from the very inception of its work. Care has been devoted to the proper arrangement, display and labeling of those parts of the collections placed on view. The late G. Brown Goode once said in substance,

'A good museum is a collection of good labels, illustrated by carefully selected specimens.' Much time and thought has been expended in the endeavor to tell to the observer in simple and intelligible language the truth which the collections are intended to illustrate. In order to enlist the interest of children a series of prizes has been annually offered to the pupils in the high-schools and the upper classes in the grammar-schools of the city of Pittsburgh. The prizes are awarded to those who shall write the best essay upon some subject illustrated by the collections contained in the Museum. Thirty-eight prizes,



A SECTION OF THE ANDREW CARNEGIE NATURALISTS' CLUB IN SESSION.

ranging in value from $25 to $2, were offered in 1900. Eight hundred and forty-three essays were submitted in competition. The decision of the awards is made by a committee of judges consisting of thirty of the most cultivated ladies and gentlemen of the city, among them a number of eminent clergymen, lawyers, editors and authors. The plan requires on the part of the contestants a personal visit to the Museum and the study of the collections. During the month preceding the close of the contest the Museum was at times crowded by eager throngs of intelligent boys and girls armed with note-books and pencils. The delicious compliment of imitation has been paid to the Carnegie Mu-

seum since this plan was adopted by several kindred institutions in America and in Europe.

A further effort to interest and instruct the youth of the community has led to the formation of a society known as the Andrew Carnegie Naturalists' Club, which consists of between two and three hundred young people who meet every other week on the afternoon of Saturday in the lecture-hall of the Museum and hear lectures, often illustrated by specimens and the stereopticon, and who read papers upon subjects of interest. During the summer months the club makes excursions in the neighborhood, and the various subdivisions receive practical instruction from the staff of the Museum in the art of collecting and preserving specimens of plants and animals.

The wider diffusion of knowledge among scientific men and institutions is provided for by the publication of the 'Annals' and 'Memoirs' of the Museum. The former appear in octavo form, the latter in quarto. This series of publications began with the first month of the twentieth century, and it is hoped will not end so long as the centuries run their course.

THE AURORA AUSTRALIS, AS OBSERVED FROM THE 'BELGICA.'

By Dr. FREDERICK A. COOK.

IN the literature of the still unknown phenomena of polar auroras, deductions have been based almost entirely upon observations of the aurora borealis. So little has been known of the south pole and of its terrestrial and celestial surroundings that the aurora australis has been omitted in the upbuilding of auroral science. From the observations of the Belgian expedition and from the reports of forgotten previous explorers, it would seem that the auroras of the south are not so brilliant or so varied in form and character as those reported from the north. Auroras in brilliant colors and in fantastic heavenly drapery are indeed rare in the regions invaded by the 'Belgica.' It should, however, be remembered that the austral phenomenon is but vaguely known. The 'Belgica's' drift covers but a small space in the great unknown area about the south pole. Nearly eight million square miles, a region as large as all North America, is still a blank under the Southern Cross. At other points within this area the aurora may appear differently. Such a condition obtains in the arctic. Nordenskiold, viewing the northern lights from the sea north of Siberia, saw displays almost exactly like those seen from the 'Belgica' south of the Pacific, but Peary and all the explorers who wintered on the Greenland side of the geographical pole have described auroras in vivid colors and fantastic forms.

The antarctic continent, which is just the region from which the southern lights can best be studied, is still unexplored, and most of it is inaccessible. If we can judge from similar latitudes in the north, the edge of this great continent of ice is an ideal latitude for effective observatories, and no doubt future explorers will seek favorable locations from which to observe this curious phenomenon.

The inhabited parts of Australasia, southern South America and Africa are too far north to offer a good station to study these phenomena. There are no convenient land projections in the antarctic, like Siberia, Norway and Greenland in the arctic, where comfortable stations could be established. From this it results that few careful studies of the austral aurora have been made. The great restless, ice-encumbered sea which sweeps around the south polar area is not favorable for such observations. Captain Cook, who, during three years, circumnavigated the globe in high latitudes, barely mentions the aurora. Ross, Wilkes and d'Urville were in the ice regions only during the days of summer, when auroras were seldom visible.

The early sealers, who in the first quarter of the last century invaded the lonely southern seas, rarely mention the aurora. From the observations of the sealers and the early explorers it would seem as if we should have a fair idea of the austral auroras, but all antarctic voyagers have devoted most of their time to skirting the edge of the pack-ice, where the sky is almost constantly veiled by a haze of either fog or snow. The fact that the pioneers in the far south have seen so little of the aurora has led to the impression that the phenomenon there is feeble, but such an impression should not be favored until we have a more thorough series of observations.

Ross and Wilkes saw a few vivid displays of draped auroras, tinged with prismatic colors, but from the 'Belgica,' which was the first vessel to spend a winter in the antarctic, we saw few colors, seldom draped, and only rarely fleeting rays which spread over a large part of the sky. Below is a table of the observations recorded by Henryk Arctowski, the meteorologist of the Belgian expedition:

TABLE OF AURORAS OBSERVED ON BOARD THE 'BELGICA' DURING THE WINTER OF 1898.

	March.	April.	May.	June.	July.	August.	September.
1	—	—	—	—	—	L.	—
2	—	—	—	—	—	—	Ad.S.R.V.P.
3	—	L.	A. V.	—	—	—	—
4	—	—	—	—	—	—	—
5	—	—	—	—	—	—	A.
6	—	Ad. R.	—	—	—	—	—
7	—	—	—	—	—	—	—
8	—	—	—	—	L.	—	L.
9	—	—	—	—	L.	—	S.A.R. Ad.
10	—	A.S. Ad.	—	A.	L.	—	R.S.A. Ad.
11	A.	L.	—	—	L.	—	—
12	A.	—	—	—	L.	—	—
13	—	L.	—	S.A.F.	L.A.S.O.	—	—
14	A.P.W.C.	A.S.O.V.R.P.	—	L.	—	—	—
15	—	A.S.Ad.R.	—	L.	L.	—	—
16	—	—	L.	—	—	L.	—
17	—	—	—	—	L.	—	—
18	—	—	—	—	—	L.	—
19	Am. V.P.	—	—	—	—	Ad. S.	—
20	A.R.V.	—	A S.	—	—	L.	—
21	—	L.	L.	—	L.S A.	—	—
22	—	L.A.	L.	A.S.R.	A.S.	—	—
23	L.	—	—	L.S.	A.	—	—
24	L.	L.	—	S. Ad.	L.	—	—
25	A.S.	S.A.R.	—	—	—	—	—
26	S.L.R.V.O.	—	—	—	—	A.	—
27	—	—	—	—	—	A.	—
28	L.	L.	—	—	—	—	—
29	A.S.	—	Ad.	—	—	—	—
30	—	—	—	—	—	—	—
31	A.	—	—	—	—	—	—

EXPLANATION OF SIGNS EMPLOYED.

A.=Homogeneous arc. Ad.=Double arc. Am.=Multiple arc. C.=Crown. F.=Flames. L.=Luminous glow. O.=Obscure rays. P.=Streamers. R.=Rays. S.=Dark segment. V.=Wavy ribbons. W.=Curtain.

In the 'Belgica,' we had been sailing among icebergs and along the ice-sheeted coast of newly discovered lands for nearly two months before we saw the first aurora. During most of this time we were above the polar circle, where the sun, during the hours of midnight and midsummer, sank but a few degrees behind the icy crust of the earth, leaving a twilight so brilliant that no stars were visible. The glancing rays of the nocturnal sun, which were thrown from peak to peak and from the mirror-like slopes into the heavens, made the night a scene of dazzling splendor, too bright to permit the display of the auroral light.

In the first days of March we found ourselves surrounded by a hopeless sea of ice from whose ensnaring influence we were unable to extricate ourselves. The long winter and the polar night, which no man had as yet experienced, now came over us rapidly. The sun daily sank lower on the sky and swept less of the horizon. The rose color of the snow, which made the summer nights charming, now changed into lilac. The open spaces of water between the restless ice-fields were being hidden under a weight of rapidly forming new ice, and the winds were moaning in prophetic despair of the coming blackness. We knew only too well that we were in the relentless grasp of a new monster, the Antarctic Ice King, and in his grasp we must remain until the thaw of another summer should release us. In this spirit of despondency and with considerable anxiety we searched the skies nightly for the heavenly glow of the aurora australis, which we hoped might relieve the awful monotony and soul-despairing darkness of the coming winter.

While skirting the edge of the pack-ice late in February we saw a star, the first since leaving the Cape Horn waters, and this little speck, though a sign of the long, gloomy night and of the polar winter, was hailed as a messenger from a new world. During the days which followed we watched with joy the increasing number of stars from night to night, but there was so much storm and the atmosphere was so thoroughly charged by humidity that a clear sky was rarely observed.

On the evening of March 12, 1898, we saw the first distinctive aurora. A faint arc was seen the night previous, but the light was so feeble that many of us doubted that the phenomenon was auroral. The few days which preceded were clear, sharp and cold. We had been so constantly showered with snow and sleet, so persistently held in banks of fog and so often driven to the verge of desperation by the violent storms which ever swept the pack-edge that this calm and silence was, indeed, a treat to us. On the evening of the 14th the sun sank out of a cloudless sky below the crackling, quivering ice of the sea. The temperature was —15 C. A light wind, which came out of the south, pierced the skin like needles. We were many hundred miles from the

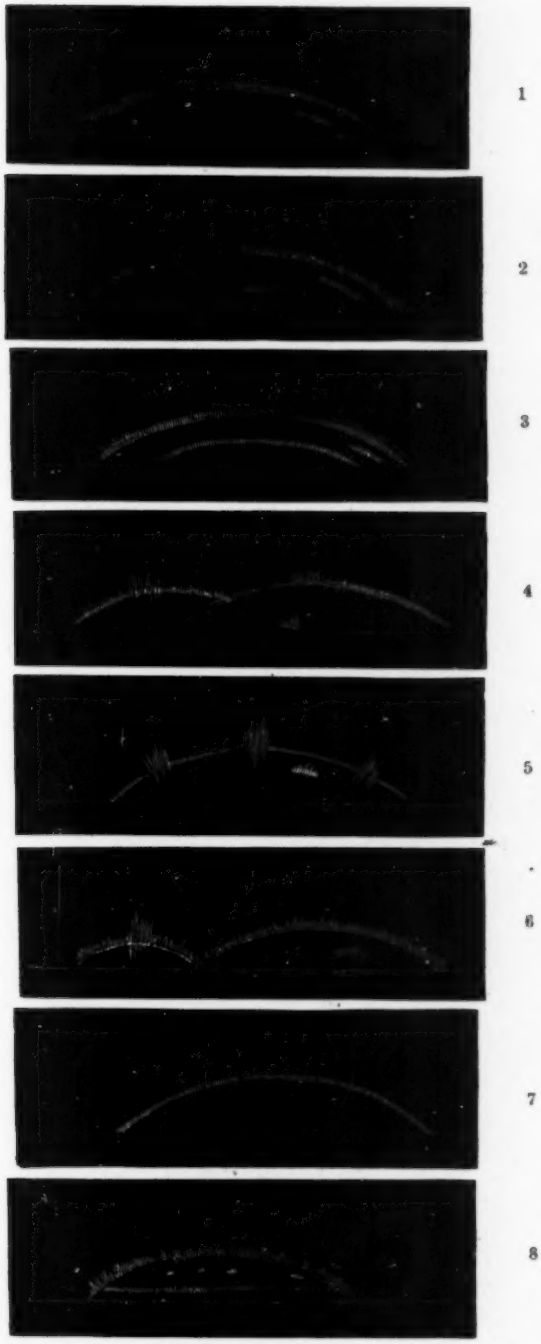
nearest land; our horizon was everywhere lined by the towering heights of icebergs which were separated by level fields of sea-ice.

Over this sheen of hard ice and soft snow there rested a haze of ice crystals which was curiously suspended in the air. As the sun sank through this haze it lost its luminous character, and before it vanished into its bed of snow it appeared as a great, distorted, rayless ball of crimson. The play of light in this icy haze is a joy experienced in no other part of the globe. Over the departing sun there remained a band of orange running into rose at the sky line and into gold at its upper edge. At the same time there rose in the east an arc of dark purple-blue, edged with orange. This is the twilight curve which is here strikingly noticeable. As the purple of twilight ascended towards the zenith, the snow westward had a delicate lilac hue, and eastward there was a bright purple-blue over everything, which finally deepened into a gobelin-blue.

At about eight o'clock the Southern Cross was clearly visible over the masts. The purple twilight curve was absorbed into the homogeneous blue of the sky. At the zenith there were a few waves of light which had the appearance of high cirrus clouds. These darted across the heavens with lightning swiftness, fading, vanishing and reappearing with augmented force each time, until at ten o'clock the phenomenon settled into a waving, luminous arc with a fringe, causing it to look like a curtain hanging low on the southern sky. Still later the fringe work gave place to a steady luminous arc, whose highest altitude was about 30°.

The evening of the 14th was also clear and calm. There was a fascinating sunset, followed by a long purple twilight. The temperature had fallen to —20 C. The glassy character of the air, the paleness of the sky and the absence of wind were to us indications of a very cold night. Such nights are always favorable to auroral displays, and we were early on a lookout for them. At about nine o'clock there appeared a bank of luminous fog in the southwest. Soon after, there rose an arc over this which was at first imperfect. Now the eastern portion was illuminated, then the western portion, and, again, only a fragment of the center was visible. So rapid were these changes that we found ourselves unable to record the fleeting forms.

Everybody was on deck or pacing the ice about the 'Belgica,' making notes and sketches of the phenomenon. The scene was such as would delight the heart of any lover of nature. The good old 'Belgica,' the home of the only speck of human life within the icy under-surface of the globe, was buried in a bed of snow which so completely covered her body that only the rigging projected. Even the masts and the ropes were encased in a heavy plating of hoar-frost and hard ice, which glittered like gems in the silvery light of the



SUCCESSIVE DISPLAYS OF A TYPICAL AUSTRAL AURORA SEEN FROM THE 'BELGICA,' MARCH 19, 1898. ABOVE THE ARCS ON THIS EVENING THERE WERE OCCASIONAL BANDS OF WAVY RIBBONS AND STREAMERS.

night. As we walked around the bark in an unsuccessful effort to keep warm we saw beyond the glittering spars the glow of a great arc. This, for a time, hung steadily between the masts and then suddenly, as if the fetters which had held it together had burst, the entire southern heavens were swept by aimless bands of fleeting luminous patches.

After a violent storm which lasted for three days the sky cleared again on the evening of the 19th; the wind then came in puffs with doleful wails like the moans of a dying soul. This we knew indicated that the tempest was nearly spent. At five o'clock I wrote in my log:

"5 P. M.—The storm has at last abated. It has left us so suddenly that the calm is as unexpected as it is appreciated. The barometer is steady and the temperature is falling fast. It is already 9°C., and is still falling. The scene now before us is full of new delights. The ice is spread out again, bright, soft and tinted with delicate colors. Every time the thick air and the gloomy storm clouds are brushed away, the pack, white and sparkling, has a new story to tell. It brings to us moods like a cheerful page in a sad story. Under the influence of this spell everybody is singing, whistling and humming familiar tunes; all are planning new work and nursing big ambitions. In the cabin the music-boxes are grinding out favorite music, which rings over the pack with a new joy. In the forecastle the men are dancing and playing the accordeon with telling effect. From some invisible point of the pack there comes a weird response to every discord of the music. It is the 'gha-a-ah, gha-a-aha' of the penguins. We have had a peep at the sun, and this has brought about an intoxication akin to alcoholic stimulation, and well it might, for the brief period of its visibility has been a dream of charms. The great twilight zone of purple, fringed with violet and orange and rose is rising over the east. The zenith is pale blue, studded with a few scarlet and lavender clouds, and the sun, a great ball of old gold, is sinking under the pearly rose-tinged line of the endless expanse of ice."

"8 P. M.—The ice shows signs of strong pressure from the north. Along the crevasses, running easterly and westerly, there are great lines of hummocks from four to eight feet in height. The colors of the pack are now far from the despairing monotone of yesterday. The yellow sea algæ have already fixed themselves in the new ice and make it appear ocherous. The twilight on clear nights is extended by the latent luminosity of the snow. The blueness of the pack in this twilight, separated by the ebony lanes of open water and decorated by the algæ-strewn yellow and green lines in the hummocks, makes the scenes curiously attractive. Added to this we have the bergs, tall, sharp and imposing, standing out against the soft blue of the sky and the hard blue of the pack as if cut from huge masses of alabaster. The

whole scene is one of lively contrasts, pleasing to the eye and stimulating to the mind, having quite the reverse of the effect of the days of darkness and depressing storms which have preceded."

At about ten o'clock we saw an aurora. It began as a ragged arc, spread easterly and westerly across the southern sky, with a straight line running under it close to the horizon. The space under the arc was noticeably darker than the surrounding sky, and in this space, also a straight line, were four luminous spots. The color of the aurora was a bright cream with an occasional suggestion of pink.

EARLY EXHIBIT, MARCH 20, 1898. ARC WITH RAYS CONVERGING TO A COMMON CENTER.

MARCH 23. FRAGMENTS OF MULTIPLE ARCS.

MARCH 24. LUMINOUS GLOW.

There was no noticeable reflection of light on the snow. A quick and constant transformation took place in the form of the phenomenon. A wave of light ran through the luminous bands and spots from east to west. Some parts brightened and enlarged, others darkened and faded away. The arcs were generally of a steady rayless brightness; the apparent movement and wavy effect of light were in a series of sharp rays on a film-like display before the arc.

I found it difficult in the low temperature to remain outside for periods sufficiently prolonged to catch the minute changes in force

and character, but I made a series of eight sketches at intervals of about twenty minutes apart, which illustrate the most striking changes. The second form was a homogeneous arc with a fragment of a second arc under it. This hung for some time, with a steady nebulous glow between it and the one previous, as well as between the intervening periods of all. The following typical forms then were rapid and almost imperceptible gradations. The third sketch represents the same position on the heavens; but under it are portions of two other arcs and a suggestion of a luminous horizontal line. At times a wave of rays, converging to the pole of the circle described, ran over the main arc. In the fourth sketch there are two arcs and a portion of a third which were seen persistently in all the exhibits to be present. In the fifth there is a second arc crossing the first. This was suggested by the

MARCH 26. EARLY DISPLAY. THIS WAS FOLLOWED BY DARTING RAYS AND WAVY RIBBONS WHICH ENDED IN A BRILLIANT ARC WITH MOVING RAYS DRAWN OVER IT CONVERGING TO A COMMON CENTER, AS SHOWN BELOW.

MARCH 26. LATER.

third, and it reappeared in the seventh. The sixth form was an arc with three ribbons of luminous beams waving from side to side. The exhibit ended with a plain arc aglow with a steady light.

For a week following we had faint auroral displays every night, but we seldom saw a brilliant or extensive exhibit. The usual form it took at this time was that of a fragment of one or several arches. On the night of the 26th we saw the usual auroral patches in the southeast which we had seen so often before. These disappeared entirely at ten o'clock, but reappeared shortly after in a manner and vividness worthy of note. There was a steady luminous bow somewhat brighter than the Magellanic clouds, and over this there were bunches of brighter rays with a rapid motion from east to west. These rays centered to a point below the horizon. Under this main arc there was from time to time a suggestion of a second and also a continuation of the same

rays which played over the main arc; above there were also occasional fragments of an arc and a prolongation of horizontal rays. This display continued until about three o'clock in the morning.

The color of this aurora, as of all those which preceded and followed, with but one exception, was a faint flesh color edged with a pale greenish-yellow. We saw no prismatic colors. The exception was a fragment of an arc in the southeast early in the evening of April 10. This was for a few moments noticeably green, but it quickly faded and vanished. Later in the evening it reappeared in the same form and place, but the color was nearly white.

In the latter part of April we saw a few auroras, especially after storms, on clear nights, but instead of increasing in number and in brilliancy, which we expected, as the veil of winter darkness was spread over us, they diminished steadily as the long night advanced. On May 17 we saw the autumnal sun for the last time. Its cold, distorted and seemingly wrinkled face lingered for a few moments on the northern ice and then sank into the frozen sea, from which it did not ascend for about seventy days. It is curious that we must say about seventy days, but this uncertainty is due to the fact that for several days before sunset the sky was obscured by storm clouds, and our constant drift with the pack-ice made our latitude uncertain.

During this long night auroras were but rarely seen, but the weather was clearer and steadier than before and after. On May 21 and 22 there were faint auroral bands in the south, on the 20th there was a feeble arc in the southeast, and on the 29th there was a feeble double arc. On the 22d, 23d and 24th of June there was a similar phenomenon in the same position, and this curiously enough reappeared one month later, in July, on the same dates. The long antarctic night, then, as experienced by the observers of the 'Belgica' was not apparently lighted by the Aurora Australis.

During August we saw but one bright display, which was a double arc, on the 20th, for most of the month was so stormy that the clear sky was seldom visible. The last week in August, however, was a remarkable period of clear weather. Bright sunlight, charming moonlight and fascinating halos were among our delights in these life-giving days of the south polar spring. The sea of ice was made doubly interesting by the increasing number of penguins and seals, crying and grunting and making manifest in various ways the contentment and satisfaction of the new sunny splendor of their usually cold and cheerless abodes. From the 'Belgica' the budding passions of a new life were bursting forth; songs and laughter and a noisy commotion were audible and visible during the evening hours.

The moon often so illuminated the skies that it was difficult to distinguish between ordinary cirrus clouds and bands of auroras. On

the evening of September 2, however, there was an exhibit which could not be mistaken. I give it as written down at the time.

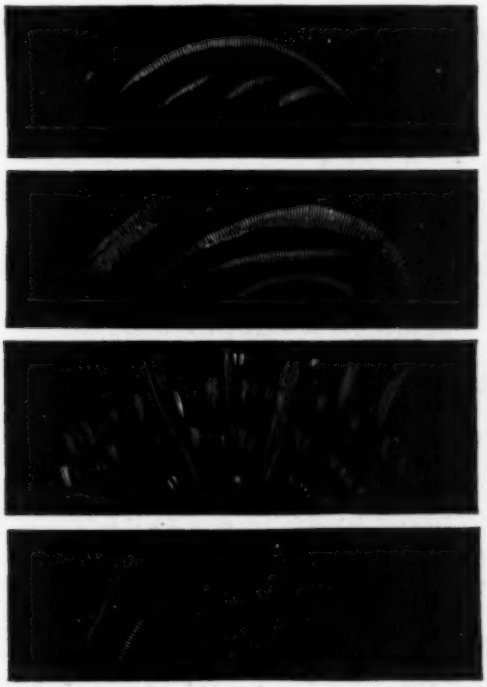
"Low down on the southern sky there stands a faint arc of light, and under it there is a distinct segment, darker than the sky above. This segment has been noticed in several previous auroras, but it was

SUCCESSIVE DISPLAYS OF AN AUSTRAL AURORA ON THE EVENING OF SEPTEMBER 2, 1898.

not before so clearly defined. On board there is considerable difference of opinion about this segment. Some have previously doubted its existence, but to-night it is indisputable. I have taken the ground that it is produced by the haze of ice crystals which always rests over the ice, and I believe that its darkness depends upon the amount of humidity or the thickness of the suspended icy haze. The stars shine

through this dark segment, apparently as bright as those above, but the light is changed in color and there is frequently a kind of halo about them. The arc gradually grows in intensity and in breadth, and it also rises a little towards the zenith. The upper edge of the segment pales as its height increases. The arc has remained perfectly regular; its two ends almost touch the horizon, and they advance to the east and to the west, widening the distance between them and showing more and more the contour of a circle as the bow of light rises."

For the first hour no beams were discernible, but the whole display consisted of an almost uniform light of a delightfully soft, cream color.



SUCCESSIVE DISPLAYS OF AN AUSTRAL AURORA. EVENING OF SEPTEMBER 10, 1898.

At ten o'clock this arc was about 15° above the sea; it was about thrice the breadth of an ordinary rainbow, and its edges were clearly defined against the dark blue of the heavens. Up to this time an air of restfulness and repose was about the phenomenon, but now this began to change to an atmosphere of mysterious excitement. A wave of light rolled slowly from one side to the other. This wave soon took on the texture of torn lacework and was drawn to and fro, while the arc, which was less brilliant, remained as it had been before. At about eleven o'clock a second arc, somewhat narrower and less brilliant, appeared below the first. The play of drapery now vanished, but in

the dark segment there appeared many glowing elongated spots all pointing toward a common circle below the horizon. These came and went with such marvelous swiftness that it was difficult to follow their forms with the eye. Still later, all signs of the aurora disappeared, except the primary arc, which had for a time at its lower edge a faint suggestion of prismatic colors. This rested motionless on the midnight heavens until about two o'clock, when it slowly faded, but before it disappeared it was replaced by a bewildering display of a rayed arc.

From September 1 to the 9th the temperature steadily fell. On the 8th the thermometer registered — 43.1 C. This was the coldest spell of the year, and it was followed on the 9th and 10th by the most vivid and impressive auroral displays that we saw. The exhibit of the evening of the 10th began in quite the usual way, with a cloudless brightness in the south. Soon there appeared an arc with its ends about 10° above the ice. Under this arc there appeared three fragmental arcs. In the course of an hour the first arc nearly disappeared, leaving only a crescent strip, but under it there were bows more or less elliptical. These vied with each other, alternately brightening and fading, and

HORIZONTAL STREAMERS AND PARTS OF MULTIPLE ARCS. EVENING OF SEPTEMBER 20, 1898.

vanishing altogether or in parts, until after midnight. At about one o'clock they disappeared suddenly and in their place came, with an electric glow and swiftness, a bewitching array of ragged patches describing four arcs. One hour later these spread over the entire heavens, making a system of quivering, moving streamers, sweeping the skies and illuminating the snows with an effect perfectly bewildering.

This was the last great aurora that we saw, and it was followed by only one other, on September 20. The night at this time was so bright that the phenomenon was barely visible, but its form was different from any which we had seen. There were two horizontal bands; between these was an imperfect arc, and on both sides were crescent-shaped patches. The whole display came and went within an hour.

It is a curious fact that the auroras usually appeared about the 20th day of the month. During the long polar night, when the boreal display is at its best, we saw very few exhibits. The phenomenon had little or no effect upon the compass, but it seemed to have some connection with the storms, for it was invariably either preceded or succeeded by violent atmospheric agitation. We did not hear any sounds,

nor could we at any time perceive an odor, both of which have been reported in connection with the northern lights.

A phenomenon which displays its glories in skies so remote and under conditions so mysterious cannot fail to excite popular interest. This interest generally suggests the question, 'What is the aurora?' This was the inquiry of ancient, as it is still the query of modern students, and our answer is the repetition of the old question, 'What is it?' We are still far from a solution of the problem. We have, however, advanced far enough to put aside many old theories, and we hope that we are now on the train of inquiries which will eventually solve the mystery.

The similarity of auroral light to that generated in a vacuum bulb by the passage of electricity, it is now believed, lends support to the proposition, suggested long ago, that the aurora is of electrical origin. It was expected that that great mystery-solver, the spectroscope, would help us in this matter, but it has only served to add further mystery to the subject. For the line which it sifts from the aurora is not matched by any other known substance. A similar line is found in the zodiac light, but this does not elucidate the matter. The zodiac light, though better studied, is still as mysterious as the aurora. When electricity passes through rarefied air it exhibits a luminous stream which seems to have the characteristics of the aurora, hence it is quite probable that this natural phenomenon is the result of currents of electricity passing through the upper regions of the atmosphere, particularly by an exchange of celestial and terrestrial electricity.

The question is, however, one of the problems of the future. Though many exploring expeditions have penetrated the icy polar solitudes, very few men have given the time and patience necessary for a systematic study of the aurora. No travelers should enter the realms of the polar lights without being prepared to record, with the accuracy required by science, the plays of this heavenly mystery. I believe that, when men shall have penetrated a little farther southward into the unexplored area about the south pole, the aurora australis will be found just as brilliant, as varied and as frequent as the aurora borealis. With our present marvelous strides in uncovering the accumulating mysteries of past centuries, we ought, ere long, to look with pride and understanding into the dark vault of the polar night and read the flaming letters which must there reveal a thrilling tale of Nature's most cherished secrets.

PROGRESS AND TENDENCY OF MECHANICAL ENGINEERING IN THE NINETEENTH CENTURY.*

By ROBERT H. THURSTON, LL. D., Dr. Eng'g,
DIRECTOR OF SIBLEY COLLEGE, CORNELL UNIVERSITY.

THE progress and tendency of mechanical engineering in the nineteenth century comprehends the progress and the tendency of almost all that has distinguished the nineteenth century from all the centuries of time, historic and prehistoric, that have preceded.

The progress of the human race includes advancement in all the languages, all the literatures, all the arts and all the sciences of all times. But the progress of past time in language is the evolution of the employment of the tongue in the conveyance of ideas, and it is the idea that is important, rather than the language. Progress in literature is the perfection of our methods of permanent preservation of ideas, and, again, it is the ideas, not the systems of preservation, that count. Progress in the sciences, in a proper acceptation of the term, is the progress of the race in knowledge of the laws of nature and the phenomena of nature, the progress of reduction of such exact knowledge to system, the construction of a code of natural law in all departments of science. Progress in the arts is advancement in the utilization of Nature's laws in the construction of a system of application of the materials and forces of nature to the enrichment and elevation of human life from its crudest and simplest forms to the highest and noblest phases of civilization. Progress in mechanical engineering is the evolution of the methods and machinery of production, transportation and utilization of the material forms of wealth. In all other directions, the progress of the world has been more or less steady, continuous and evolutionary from the beginning of the life of the race; in the sciences and the arts, it has been an evolution mainly of the later times, though having an origin prehistoric.

Progress in mechanical engineering, the production of permanent wealth in most part, could only come after language should have supplied a satisfactory vehicle for ideas; it could only begin after literature should be competent to furnish a means of storage of ideas and of knowledge in safe and accessible treasuries; it could only progress rapidly after science had accumulated sufficient store of knowledge of facts, of phenomena and of natural law to permit complete reliance upon

* An address delivered before the Washington Academy of Sciences, Columbian University, February 19, 1901.

that stock of substantial learning in the effort to develop the resources of nature for use; and such advances could only go on, unimpeded, after the nature of the great sources of power in the world should have been discovered and their availability for the purposes of the engineer recognized. Mechanical engineering, as we understand it, could only fairly start in its wonderful progress after the mechanic had found ways of utilizing natural forces and energies, and of making the tools with which to produce these prime motors, through the operation of which all the arts could be given application in the production of wealth, multiplying the power of the unaided hand by making it in the performance of work the guide of greater powers, rather than the tool itself. It was only when mighty powers could be thus developed and guided and directed that mighty tasks could be performed by so weak and insignificant an organism as man. Man as a prime mover is feeble and helpless before the great powers of nature; man as the master and guide of nature's powers is only less than omnipotent.

Mechanical engineering, to achieve its highest tasks, must have control of the grandest powers of nature and of all her energies; it must avail itself of prime movers transforming all actual and potential energies into available, transformable, useful work; it must be capable of making for itself tools and machines and apparatus, scientific and other, competent to direct those energies in definite and helpful ways to the performance of every useful task. Progress must wait for the power and power must be guided, divided, applied, through invention and the mechanic arts, to defined and precisely related productive operations. The natural order is: first, sources of available energies; second, prime movers applying while developing those energies; third, tools and machines devised and constructed to perform detailed tasks, exactly and perfectly. Invention is the first necessity, and necessity has been found to be the mother of invention; but invention is helpless without tools, and invention began with the first crude tools; the motors followed, and better tools followed motors, and better motors followed the invention of better tools. It was only a century ago, or a little more, when the inventor had reached a certain stage in the production of tools, that Watt could produce the steam engine of the nineteenth century, that a system of manufactures could come into being as the fruit of invention and that the Golden Age of the centuries could begin.

The Golden Age of the World, in all good senses, had its origin with the birth of the nineteenth century, and when mechanical engineering began uniting all the sciences and all the arts into one great system of adaptation of nature's powers to the work of the promotion of civilization. This fairly begun, the steam-engine, the gas-engine, the electric motors and generators, telegraphs and telephones, the steamboat, the locomotive, the automobile, textile manufactures, iron and steel

making, shortened working hours for the people came and leisure for the enjoyment of the best that life affords, for thought, for contrivance, for self-communing, for self-exaltation in spiritual realms, became a birthright with mankind.

Mechanical engineering is the highest illustration of applied science; and applied science is the fruition of pure science. A fundamental basis for mechanical engineering could not be secured until physical science could find safe development, and this could only be when, the age of martyrdom past and perfect freedom of thought and research assured, later Brahes and Galileos could work in peace and Gilbert and Lavoisier and Faraday and Davy and their successors could devote themselves to their labors in all the fields of science without molestation. Invention could not freely develop the arts until after these master-minds had assured freedom to the more modest but none the less glorious workers in science and the arts, and to the mechanics and the inventors, and had secured that political and social freedom to work in any and all fields, irrespective of birth and caste and creed, which has only, even now, been witnessed in America. When absolute liberty of mind and body and freedom of choice of vocation had become possible without dictation by church or state or convention; when any man could pursue research and publish results, and could follow any art and could give vent to his highest and best aspirations and impulses—only then could steady progress become possible.

It was only in the nineteenth century that a Darwin could safely pronounce his judgment, that a Spencer could formulate a system of philosophy, that a Huxley could declare his conviction and a Haeckel could face the dogmatist and that warfare between science and dogma could no longer effectively repress honest work and sincere conviction. It was only in the century lately closed that the mechanic could take up any trade, without regard to the caste of his fathers, that progress became easy for the scientific Papin, the clerical Cartwright and the physicist Black, or that the instrument-maker Watt could proceed with the evolution of the heat-engines. Only in the nineteenth century came it to pass that the inventor, impelled into any line of study and experiment and labor, could unite with every other man in the same field to perfect the machinery of the world, and that invention could build up nations like Great Britain and the United States, and give wealth to Germany and to France. Only in the century just closed did it become possible to gain freedom in the competition of brain with brain for all men.

The political freedom of the United States and its admirable policy and its practice of encouraging invention by wise patent laws have now made our country the leader among nations in all fundamental modern industries.

At the opening of the twentieth century we have far better occasion than had at any time the great cynic, Carlyle, to exclaim:

"The Present Time, youngest-born of eternity, child and heir of all the Past Times, with their good and evil, and parent of all the Future, is ever a 'New Era' to the thinking man; and comes with new questions and significance; however commonplace it looks: to know *it* and what it bids us do is ever the sum of knowledge for all of us. This new Day, sent us out of Heaven, this also has its heavenly omens—amid the bustling trivialities and loud empty noises, its silent monitions; which, if we can not read and obey, it will not be well with us! . . . . But, in the days that are now passing over us, even fools are arrested to ask the meaning of them; few of the generations of men have seen more impressive days. . . . There must be a new world if there is to be any world at all! . . . One thing I do know," he adds, . . . "That the few Wise will have, by one method or another, to take command of the innumerable foolish; that they must be got to take it; and that, in fact, since Wisdom, which means also Valor and heroic Nobleness, is alone strong in this world, and one wise man is stronger than all unwise, they can be got."

How shall the wise men and the wisest men accomplish their tasks? I take it that Carlyle was also right when he prescribed the two great tasks lying before us:

"Huge-looming through the dim tumult of the always incommensurable Present Time, outlines of two tasks disclose themselves: the grand Industrial of conquering some half or more of this Terraqueous Planet, for the use of man; then, secondly, the grand constitutional task of sharing, in some pacific, endurable manner, the fruit of said conquest and showing all people how it might be done."

"Moreover," he goes on, "there are spiritual budding-times, and then also there are physical appointed to Nations.

"Thus, in the middle of that poor calumniated Eighteenth Century, see once more! Long Winter again past, the dead-seeming tree proves to be living, to have been always living, after motionless times, every bough shoots forth, on the sudden, very strangely—it now turns out that this favored England was not only to have had her Shakespeares, Bacons, Sydneys, but to have had her Watts, Arkwrights, Brindleys! We honor greatness in all kinds. . . . Prospero can send his Fire-demons panting across all oceans; shooting with the speed of meteors, on cunning highways, from end to end of all kingdoms; and make Iron his missionary, preaching *its* evangel to the brute Primeval Powers, which listen and obey. . . . Advancing always, through all centuries, in the middle of the eighteenth they *arrived*. The Saxon kindred burst forth into cotton-spinning, cloth-dropping, iron-forging, steam-engining, railwaying, commercing and careering towards all the winds of Heaven."

Carlyle saw more clearly than perhaps any other man of his time that, as others have since said, the world owes absolutely nothing, in its conquest of the forces and powers of nature, to the kings and princes or to the aristocracy of the worlds, past or present; they, with their battles and contentions and their subordination to their own insignificant affairs of every element of real progress, have been the great impediments to progress. The world owes all rather to the inventor, to the mechanic, to the man of science and the man of mind. All progress has been effected irrespective of, if not in spite of, the acts and famous deeds of

kings and warriors, and through the arts of times of peace, or through revolutions which have been effective protests against the infringement of liberty and the restriction of the worker. Science, applied science, invention and the industrial army have done the work.

With the opening of the twentieth century we are indeed arrived at a Day of Great Things, the fruition of all those forces and movements and evolutions which have been the characteristic features of the history of the nineteenth century. All great works are performed on a mighty scale, and the advances of the industrial army are now made through wide-spread and far-reaching movements of army corps, instead of, as but two or three generations ago, in a thin and straggling line of individual skirmishers. All the world is falling into line, and the whole world-wide army is moving in concert if not under a single generalship. In the industries, the captains of industry, once commanding squads and companies, now are become majors with their battalions, colonels with their regiments, generals with their brigades, their army corps, with mighty armies overspreading all the fields of production of a whole country, even of many countries. Where the single worker labored hour by hour through the long day, 'from sun to sun,' in the days of our grandparents, companies of workers now cooperate, by subdivided and wonderfully trained tactile talent, in a single multiplex task; the squad of workers in the little factory or mill has grown into an organized body numbering regiments. A whole industry is organized and supplies an enormously expanding market with continually improving product, at steadily declining costs and prices, while, at the same time, giving its armies of workmen and workwomen steadier work, at better wages, under more reasonable and comfortable conditions, day by day and year by year. The higher the wages paid and the shorter the working hours, the less the cost and the lower the price of the product, the greater is the purchasing power of the day's work and of the dollar paid the worker. This is the nineteenth century statement of the Law of Supply and Demand.*

Goethe, poet, man of science and seer, prophesied that the nineteenth century would solve the problems of organization of the industries and the great social and economic problems of an industrial epoch. Carlyle saw the same problems in progress of solution, and his disquisition on the organization of labor as the problem of the coming days shows that great men here thought alike. Hitze defines the standing problem of our time, the problem of the nineteenth century, particularly—already partly, yet not wholly, solved—to be that of finding a social organization corresponding to the modern conditions of produc-

* The Modern Version of the Law of Supply and Demand.—R. H. T.—Science, 1898.

tion; just as the social organization of the Middle Ages was adapted to the simple industrial conditions of that time.* Henry Dyer's 'Evolution of Industry'† traces this process of solution of these problems, so far as solved to date, in a most interesting way. His conclusion, that the mechanical development of the past century is a necessary element of the evolution of society, as well as of the industries, is as sound as is his deduction that the problems of the twentieth century should be solved in such manner as to insure a final evolution of an ideal, discreet, wise, prudent, pleasant and righteous life, which shall conform to the ideals of the scholar, the gentleman, the seer and the poet. On the organization of the mechanical industries largely depends the future of the world, and in this evolution of a finer and better life, through industrial and social evolution, the influence of one such man as Dolge, at Little Falls, N. Y., and of one such firm as the famous Patterson's at Dayton, Ohio, tells more powerfully than all polemic discussion.

Thus the organization of the workshop and the humanizing of the workman, as Ashbee denominates it, may be expected to proceed together.‡

The noble view of the Bishop of Durham, as expressed a few years ago, may well be taken as the enunciation of the problem and the purpose of the coming centuries:§

"Manufactures, trade, commerce, agriculture, if once the thought of personal gain can be subordinated to the thought of public service, offer scope for the most chivalrous and enterprising and courageous. It can only be through some misapprehension that it seems nobler to lead a regiment to the battlefield than to inspire the workers in a factory with the enthusiasm of labor."

He anticipates, nevertheless, that the time is coming, surely if slowly, but possibly quickly, when the Great Industry will be "made to contribute to the material and moral elevation of all who are engaged in it, not as separate or conflicting units, but as parts of the social organism."

In his remarkable little book, 'Our Country,' Dr. Strong, fifteen years before its close, affirmed that the later years of the nineteenth century constitute a 'focal point' in history, and are second only in importance to "that which always must remain first, viz., the birth of Christ." He goes on to say in his introduction:

"Many are not aware that we live in extraordinary times. Few suppose that these years of peaceful prosperity, in which we are quietly developing a continent, are the pivot on which is turning the nation's future. And fewer still

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* 'Die Quintessenz der Socialen Fragen.'

† 'The Evolution of Industry'; By Henry Dyer, C.E., M.A., D.Sc., New York and London, Macmillan & Co., 1895.

‡ 'Workshop Reconstruction and Citizenship.'

§ Economic Review, October, 1894.

imagine that the destinies of mankind, for centuries to come, can be seriously affected, much less determined, by the men of this generation in the United States."

The nineteenth century has been the first distinctively machine-using period. Until heat-motors could be found, it was impracticable to employ machinery in any very great extent in the performance of the work of the world. Until entire freedom of the worker could be assured, enabling him to devise and to find means of constructing machinery, inventions could not find general use. Until the machines for machine-making could be had, the general use of machinery could not be secured, simply because the finer classes of machinery could not be accurately and satisfactorily made. Until the modern system of manufacturing and of working to gauge, and of interchangeable parts, could be adopted, the production of an industrial system for mechanical production was not practicable. Thus all kinds of mechanisms and every department of invention waited upon every other until, nearing the beginning of the nineteenth century, the long-delayed conjunction was attained, the beginning of the machine-using age introduced a new era, and the world took a sudden leap forward; thenceforward advancing with a continuous acceleration. Then came a machine-using world. Then one man became equal, in productive power, to two or five, or sometimes to ten, or even to a hundred, lacking the aid of the machine. For the first time in the history of mankind, a real, permanent, rapid and rapidly increasing progress began. One man then became able to do the work of four of his predecessors in making agricultural machinery, and he made it incomparably better; one man could do the work of fifty in making gun-stocks, after the Blanchard lathe for turning irregular forms had been adapted to the task of aiding him. One man does the work of six in boot and shoe making; in some departments of textile manufacture one man with his machinery does the work of a hundred of earlier generations. In fact, the earlier generations from prehistoric days have no record of any very important progress. Each man, with his modern newspaper-printing press, taking its paper from its miles of rolls, printing, cutting into sheets, pasting together, folding and piling ready for the carrier, does the work that five hundred men would have been employed to do a century earlier, and then it would have been a work very badly done, as gauged by our standards. Mr. Wright reckons that the machinery of the United States gives the power of doing work that, without it, would require the labor of a hundred millions of workers; thus multiplying the average work of the average individual worker by about six.* In a very large proportion of the later developments, especially in the application of steam-power,

* 'Industrial History of the United States'; Chautauqua-Century Press, 1895.

the task of the machine could not be performed at all; as, for example, the haulage of the railway train at the rate of a mile a minute or more, or the driving of a transoceanic liner across three thousand miles of stormy seas at the speed of fifteen to twenty-five miles an hour. A large fleet would be required to carry the labor and provisions for a single craft, equivalent in total power, driven by animal force.

It has been the use of machinery that has permitted the people of our country to use twenty pounds of cotton *per capita* where they formerly used but five; to increase their consumption of iron and steel from a few pounds to four hundred *per capita*, and the consumption of steel from an insignificant amount up to two hundred and fifty pounds and over. This use of machinery and universal extension of mechanical engineering has even permitted the doubling of our population in the last generation and the increase in the number of people employed in productive vocations one hundred and seventy-five per cent., according to Mr. Wright's statistics. One-sixteenth of the whole population of the country is supported by labor in railway transportation, and the once minute proportion engaged in coach and other transportation by means of horses has been multiplied many times over; yet these people were the most vigorous and powerful of all opponents of this advance.

The sewing machine, giving the power of multiplying many times the productivity of the needle, instead of displacing the sewing girl, as once anticipated by many ignorant persons, proves to be not properly a labor-saving machine, but a machine assisting labor and multiplying not only the efficiency of the worker, but also many times increasing the quantity of work to be done and the numbers needed for the work, as occurs in all such cases. In a thousand instances the invention of a machine or the introduction of a new method in some department of mechanical engineering has brought into use an entirely new form of industry and made effective and productive the highest powers of thousands of people who otherwise would probably be compelled to drudge on in old ways and to content themselves with old rates of compensation. The reduction of costs of product and the increase in the wages of labor are the two most striking results of the revolution of the century; while the accession of value conferred upon material is sometimes quite as impressive, if not actually as important—as when the often-recounted fact is noted of the increase of the value of iron from one dollar in the ore to five or six in the shape of iron bar, to $10 in any one of many finished machine-made forms, to $200 and upward in fine cutlery, to $5,000 and $10,000 in needles, to $200,000 and more in common watch-springs, and to perhaps half a million dollars in the shape of hair-springs, the most refined condition of the metal yet attained, or even up to $2,500,000, according to Mr. Woods, in the form of pallet-arbors.

The earlier days of the factory system, while an improvement upon what had preceded, were not particularly promising, as viewed from this latter-day standpoint. The manners and morals of the time were necessarily imported into the factory, and, while the working men and women and children soon gained a higher plane of comfort, that level would seem to us an exceedingly small advance upon the conditions of the Middle Ages. The hours were long, the wages low, the social conditions in all respects still unsatisfactory. Women and children were flogged for actual or imputed idleness, for incompetence, or even for lack of endurance and of strength. But the output soon filled the markets of a then poor and moneyless people, and wages and prices began to readjust themselves, as always, to the new commercial conditions, and the end of the century has found the operatives organized and powerful, knowing and compelling fair treatment, sometimes even tyrannizing over the employer, indeed, but usually simply securing by force what is fairly theirs and can not be otherwise obtained. Wages have risen and prices fallen, until the day's work earns several times as much as a century ago. Moral tone has improved as social conditions have thus been improved, and comfortable houses, plenty of good food and many of the luxuries of the beginning of the century are taken as ordinary comforts by the operatives of to-day. Then the wealth of the country was $320 *per capita*, to-day $1,350; then it aggregated seven and a half millions, to-day its total is about a hundred billions, increasing thirteen times, while the *per capita* account has risen to four times its initial figure. In a half-century these workers have increased their *per capita* account as depositors in the savings banks from about $175 to about $400; the total deposits growing from something over forty millions to about twenty-five hundred millions. The factory system is also the source of all labor legislation, and this, on the whole, splendidly beneficent code is thus due to the perfection of the methods of mechanical engineering. Society is advantaged from top to bottom and in every class, most of all in the humblest.

While it is true, as I have sometimes asserted, that "great movements, whether of mind or matter, of nations or of plants, of civilization or of comets, have definable rate and path," and while it is the fact that, as I have put it, 'Nature turns no sharp corners' in such mighty fluxes of energies, it is nevertheless true that some of her movements have paths of considerable deviation from the right line, and some of the motions illustrated are occasionally almost as tremendous accelerations as is the irruption of the volcano after its long period of preliminary development and storage of energy. The process of evolution is continuous; but its action involves every variety of acceleration and visible change, even though the evolution is itself a steady operation. We see only portions of its action and lose sight of its continuity and

its steadiness. So it has happened that the nineteenth century has illustrated such an apparent, though not real, exception to the law. The forces of civilization had been cumulative; the resultant forces gathering through the earlier ages, partly stored and latent, but none the less potential, and partly as the actual and kinetic energies of phenomena of visible evolution. All energies seem to have become kinetic and visible in their aggregate results in this Victorian Era. The outcome has been described as a 'tidal wave' of upward and onward movement on the sea of universal progress, a climax of an evolution of which the earlier periods have been quiet and silent and simply those of preparation. It has been like the action of the seas beating upon a yielding shore. Slowly and steadily through the ages it cuts farther and farther into the obstruction, unobserved and unrealized as a great natural movement, until, at last, the dike is cut through and the ocean rushes in and overflows the land. This flood, beneficent as the other might be destructive, has had a somewhat similar history. The nineteenth century is the period of uprush and inrush of the flood of efficiently applied human intellect, making effective al those powers which have been till now frittered away, the magnificent potentialities of which have never been before realized.

This volcanic development of previously latent, but gathering and cumulative, energy has been effective in every department of human activity, but most of all, perhaps, in the field of invention, of the mechanic arts, of what we have come to-day to designate 'mechanical engineering.' The acceleration has been one beside which that of the falling stone or a dropping shot or the meteor precipitated into the field of attraction of our globe seems insignificant in resultant effects. In the year 1800 we had not a locomotive or a railroad for public service in the world. To-day the United States alone, with half the mileage of the world, possess 200,000 miles, nearly, of rail and about 40,000 locomotives. Then we had no telegraph; to-day its wires span the continents and carry messages along the bed of every ocean, binding the continents as with ties of steel. Over three millions of miles of wire transmit three hundred to four hundred millions of messages annually, and nations are brought within speaking distance and bound heart to heart. The events of the antipodes are signalled to us, hour by hour, as they occur, and we read at the breakfast table of battles, coronations, deaths and births of individuals and of nations, of all the great phenomena of a world, from Atlantic to Pacific and to Atlantic again, and almost from pole to pole.

(To be concluded.)

PRIMITIVE COLOR VISION.*

By Dr. W. H. R. RIVERS,
ST. JOHN'S COLLEGE, CAMBRIDGE UNIVERSITY.

THE importance of language as an instrument of anthropological enquiry has been the subject of much difference of opinion. On the one hand, there are those who believe that the relation between language and thought is so close that the former has always been an almost exact mirror of the latter, and that every increase in intellectual development has been accompanied by, if not conditioned by, a corresponding increase in the development of language. On the other hand, the tendency which perhaps now prevails among anthropologists is to attach too little importance to language as an indication of the mental development of a race. The subject of the color sense of primitive races is one which is especially useful in studying how far the capacity for appreciating differences goes with the power of expressing those differences in language. We are able to put to the test how far the ideas of a people may be deduced from their language. We can collect the epithets used for color in various races, both of the present and of the past, and from a study of these epithets we can draw conclusions as to the nature of the color sense in these races. In the case of still existing races, we can then examine the color sense objectively and ascertain how far the conclusions derived from the study of language are verified by the result of the objective examination.

Historically, this is more or less what has been done. In 1858, in his 'Studies on Homer and the Homeric Age,' Gladstone called attention to the great vagueness of the color terminology of Homer; he showed that Homer used terms for color which indicated that his ideas of color must have been different from our own, and he was inclined to go as far as to suppose that Homer had no idea of color as we understand it, but distinguished little beyond differences of lightness and darkness.

Ten years later, Geiger,† from a more extended investigation of ancient writings, also came to the conclusion that the color sense of the ancients must have been very defective. He found, not only in Greek literature, but in the Vedic hymns of India, in the Zendavesta, in the Norse Edda, and in ancient Chinese and Semitic writings that there was evidence of great imperfection, especially in the names for green and blue. In hardly any of these ancient writings is any word used from

* A lecture delivered at the Royal Institution, January 25, 1900.

† 'Contributions to the History of the Development of the Human Race,' p. 48.

which we may gather that the people who wrote them had any idea of blue. Geiger advanced the view that there had been an evolution of the color sense in historical times; and he supposed that this evolution had been of such a kind that red had been distinguished first, followed by yellow and green, and that the sense for blue had developed much later than that for the other colors. Magnus* came to the same conclusions on the basis of a still more extended examination of ancient writings, and Gladstone, in 1877, again called the attention of English scholars to the subject in the pages of the 'Nineteenth Century.'†

The subject was taken up both from the literary and scientific points of view. On the literary side it was objected that the special peculiarities of the color terminology of Homer were due to a characteristic of epic style, according to which attention is paid to form rather than to color. It was also pointed out that the language of some modern poets presents the same peculiarities as those of ancient literature. Grant Allen‡ counted the color-epithets used in Swinburne's 'Poems and Ballads' and found that red occurred much more frequently than blue, and a similar preponderance of red was found to be a feature of Tennyson's 'Princes.' Instances were also given of individual peculiarity in the use of color by many modern poets, one instance being La Fontaine, who, according to Javal,§ only used an epithet for blue once in the whole of his poems.

On the scientific side, also, objections were raised. It so happened that about 1877 there were in Germany two parties of Nubians going from town to town in traveling caravans. These Nubians were examined by Virchow and others, and it was found that they exhibited the same peculiarity of color language as ancient writers; they had no word for blue, or, rather, they used the same word for blue as for black or for dark colors generally. On examination, it was found, however, that they were not color blind, and that they sorted colored papers and wools correctly. It was, therefore, concluded that the ideas of Gladstone and Geiger were altogether erroneous, and that there was no necessary connection between color sense and color language.

In this country the views of Gladstone and Geiger were submitted to a comprehensive criticism by Grant Allen in the book, 'The Color Sense,' already cited. The strongest objection raised by this author was based on the existence of a well-developed color sense in many of the lower animals, and it was argued that this sense could not therefore be defective in primitive man. He also brought forward evidence that many existing primitive races made large use of color, and cited the

* 'Die geschichtliche Entwickelung des Farbensinnes,' Leipzig, 1877.

† Vol. II., p. 366; 1877.

‡ 'The Color Sense.' London, 1879; p. 264.

§ 'Bull. de la Soc. d'Anthropologie de Paris.' T. XII., p. 480; 1877.

opinions of travelers that savages were able to distinguish colors perfectly. He also pointed out that the decorations of the early Egyptians and of other ancient races showed the existence of a well-developed sense long before the time of Homer.

The controversy was carried on for some years, especially in Germany. Magnus* showed that the same defect of terminology for green and blue, which characterizes ancient writings, still exists among many primitive races at the present day, and argued that this wide-spread peculiarity must have had some definite cause, probably of a physiological nature. Nevertheless, the general trend of opinion was strongly against the views of Gladstone and Geiger, and the idea of the evolution of the color sense in man has been almost universally rejected.

As a member of the anthropological expedition which went out from Cambridge to Torres Strait and New Guinea in 1898, under the leadership of Prof. A. C. Haddon, I had an opportunity of re-investigating this question. In addition to a full examination of the color vision of two tribes of Papuans inhabiting one the eastern and the other the western islands of Torres Strait, I was able to make observations on natives of the Island of Kiwai, at the mouth of the Fly River, and on members of several Australian tribes. The languages of these people showed different stages in the evolution of color terminology, which correspond in a striking manner with the course of evolution deduced by Geiger from ancient writings. In an Australian tribe, from the district of Seven Rivers, on the eastern shore of the Gulf of Carpentaria, several natives only used three color epithets; red, purple and orange were called by the same name, 'ŏti'; white, yellow and green were called 'yŏpa,' while black, blue, indigo and violet were all called 'manara.' Other natives from an adjoining tribe used the names 'owang,' 'wapŏk' and 'unma' in the same sense; some natives applied other names to green and yellow, but those given appeared to be the only terms which were used with any definiteness and constancy.

The next stage in the evolution of a color vocabulary was found in Kiwai. In the language of this island there was a very definite name for red, 'dŏgó-dŏgó,'† and a less definite name for yellow, 'agó-agó agó-agó.' Greens were called by most individuals, 'emasóro' and 'tigiro,' which were also used for white and black respectively, and may probably be translated 'light' and 'dark.' A few used a special word for green, 'poroporona.' Blue and violet were usually called 'wĭbu-wĭbuna,' the word for black, others calling these colors 'tĭgiro' or 'pŏropŏrona.' The brilliant blue of the sky received from these people the same name as the deepest black.

* 'Untersuchungen über den Farbensinn der Naturvölker, Jena, 1880,' and 'Ueber ethnologische Untersuchungen des Farbensinnes,' Breslau, 1883.

† 'Ó' stands for the sound of 'aw' in the word 'law.'

In Murray Island, in the eastern part of Torres Strait, where we stayed for four months, I was able to investigate the language used for color very completely. In this island there was a very definite name for red, 'mamamamam,' while several other names, such as 'kiamikiam,' 'erŏko, mamamamam' and 'somer-mamamamam,' were used for purples and pinks. There were two definite names used for both orange and yellow, 'bambam' and 'siusiu,' and one definite word for green, 'soskĕpusoskĕp,' while several other words were occasionally used. There was, however, no native name for blue, apart from that used for black, 'golegole.' This word was used by many of the older men, and, as in Kiwai, the brilliant blue of the sky and the deep blue of the sea would often be called by the same name as the darkest black. Many of the natives had, however, adopted the English word, which, by re-duplication and separation of contiguous consonants, had become 'bŭlu-bŭlu,' and many of the younger men believed that this word belonged to their own language.

The color language of the western tribe of Papuans in Torres Strait was fully investigated in the Island of Mabuiag. Here the vocabulary was more definite. There were a limited number of terms which were used by nearly all for the chief colors. Red and yellow were called 'kulkadgamulnga' and 'murdgamulnga' respectively. There was a fairly definite term for green, 'ildagamulnga,' which was, however, sometimes used for blue, and there was a term for blue, 'maludgamulnga,' which was also used not infrequently for green. In addition to these four more or less definite color names, other terms were used for different shades, and a few natives showed extraordinary ingenuity in devising special names, apparently on the spur of the moment, for different shades of color. I have a list of over thirty such names from one individual, all derived from a comparison with natural objects.

In these four languages of Seven Rivers, Kiwai, Murray Island and Mabuiag, we have progressive stages in the evolution of color language; in the lowest there appears only to be a definite term for red apart from white and black; in the next stage there are definite terms for red and yellow, and an indefinite term for green; in the next stage there are definite terms for red, yellow and green, and a term for blue has been borrowed from another language; while in the highest stage there are terms for both green and blue, but these tend to be confused with one another. It is interesting to note that the order in which these four tribes are thus placed, on the ground of the development of their color language, corresponds with the order in which they would be placed on the ground of their general intellectual and cultural development.

It is said that there are other races, such as the Todas of Southern

India, who have only three definite terms in their color vocabulary, viz., those for red, white and black, while others have also a term for yellow. The absence of a definite term for blue, on the other hand, is very common. The languages which have this characteristic appear to fall into two main classes; those which, as in Kiwai, have the same word for blue and black, and those which have the same word for blue and green. The former class includes the languages of Hovas and Bushmen, as well as of many Australian and Melanesian tribes. The second group comprises a very large number of languages, including one so near home as Welsh, in which there is only one word, 'glas,' for both green and blue.

By many races a word for blue has been borrowed from some other language, as was the case in Murray Island; thus many African races are said to use the term 'bru,' obviously a corruption of the English word; in South America the Spanish word 'azul' has been borrowed, and the Battas of Sumatra have borrowed words both from Dutch and Malay. The word used by the Ga people of the Gold Coast for blue and for indigo is said to mean literally 'something that must be learnt,' these people having been taught the use of indigo either by Europeans or by other Africans.*

When in Ceylon I obtained color vocabularies from a number of Singhalese and Tamils, and, though the two languages differed in other respects, both Singhalese and Tamils used the word 'nīl' or "nīlam' for blue, and this word, which is said to be the same as the name of the river Nile, is found widely distributed among Asiatic languages. The river Nile has another interest in connection with this peculiarity of color language. We are in the habit of speaking of the White Nile and the Blue Nile. The Arabic name for blue is 'azrag,' a word used by the modern Egyptian for blue and for dark colors generally. 'El Bahr azrag' probably originally meant the dark Nile, and, when we speak of the Blue Nile, we are using an expression which is based upon the primitive confusion between blue and black.

Magnus has shown that these defects in color nomenclature cannot be referred to the poverty of language. Some races, such as the Kaffirs and Basutos of South Africa, who have no word for blue, have, nevertheless, a very long vocabulary for the various colors of oxen. Similarly, the Kirghises,† of Central Asia, have many different names

* For many other instances of defective color terminology among savage and semi-civilized races, see the papers of Magnus already quoted, and also Andree, 'Zeitsch f. Ethnologie,' Bd. X., p. 328; 1878.

† Radloff, 'Ztschr. f. Ethnol.' Bd. III., p. 285; 1871.

for the colors of horses,* though they tend to confuse the designations for green and blue.

I have had an opportunity of examining the color vision of the Eskimos who have lately been in London, and have found that their language presents a very striking contrast to that of the tropical people, to whom my previous work had been limited. The terminology for color appears to be extremely well developed; there are definite names for red, yellow, green and blue, and modifications of these colors are expressed by means of suffixes or by compounding two names; thus, by more than one individual a purple was called 'aupaluktaktungalangaijuk,'† which means bluish-red, while a violet was called 'tungajuktakaupalangaijuk,' which means reddish-blue. This recognition of the fact that violet and purple are mixtures of red and blue shows a high degree of definiteness in the nomenclature of both colors. I have only met with one other individual who behaved in a similar way, viz., a Tamil, who called purple 'sikapu-nilam,' red-blue.

Another peculiarity which appears to characterize a very large number of languages is the absence of a word for brown. In Torres Strait a native would call one brown by a name meaning 'reddish'; another brown by the same name as yellow, while others would be called dark or gray. It was quite clear that they had no generic name for brown. In the Australian and Melanesian languages, I have had the opportunity of studying, as well as in Tamil, Singhalese and Eskimo, I have failed to find any definite term for brown, and the same defect is found in Welsh and in many other languages. The word given for brown in many vocabularies is obviously the same word as that used for red or dark or gray. There is always a danger that one may accept, as a generic name for brown, a word which is only a name for a special brown. This was very well shown in Mabuiag, where brown wools were by some natives called by such names as 'wamauwibadgamulnga' (honeycomb colored), or 'wabadgamulnga (Dracæna colored), but it was quite certain that these were names used by certain individuals for special browns and were in no sense names for brown in general. Similarly, in other languages in which there is no word for brown there may be names for special browns, such as names for the colors of horses or cattle, but such terms are limited to those objects. We have in our own language similar examples in the words 'bay' and 'dun.'

The idea of brown is so definite with us that it is surprising that a word for brown, and apparently the generic idea of brown, should be

* Strictly speaking, these names and those of the Kaffirs are not names of colors, but rather names for distribution of color and marking; thus among the Kirghises a brown horse with a black mane and tail would have one name, and a brown horse with a white mane and tail, another name.

† 'Au' stands for the sound of 'ou' in 'house,' and 'ai' for that of 'i' in 'ice.'

absent from so many languages. The fact is perhaps the more strange in that the word 'brown' bears evidence of having arisen in an early stage of our language, and is not, like violet or orange, obviously of recent origin.

The special characteristics of primitive color language appear, then, to be the following: The existence of a definite name for red, sometimes with subsidiary names for shades of red; a definite name for orange and yellow; indefinite nomenclature for green; absence of a word for blue, or confusion of the terms for blue and green, and absence of a word for brown, a brown object being called red, yellow or dark, according to its prevailing character.

These features closely resemble those of Homer's color terminology. Homer uses several words for red, φοῖνιξ, φοίνιος, μίλτος, ἐρυθρός and πορφύρεος; he has a definite word for yellow, ξανθός, an indefinite word for green, χλωρός; and no word for blue. Two words which later came to mean blue, γλαυκός and κυάνεος were used by Homer, but it can not be said that the terms mean more than 'light' and 'dark' respectively. There seems now to be little doubt that κύανος, the substance, was 'lapis lazuli' and also an imitation of this substance made by coloring a glass paste with salts of copper, but κυάνεος is not used by Homer as an epithet for any distinctively blue object (except κύανος), while it is used for a perfectly black garment.* The substance, κύανος is also qualified in one place,† as μέλας.

There appears, also, to be no word for brown in Homer, but brown or brownish objects are qualified by the same adjectives which are used for red, thus φοῖνιξ‡ is used for the color of a horse, and ϑαφοινός is applied to jackals§ and the skin of a lion.¶

The resemblance is so striking that the conclusion seems irresistible that we have to do in Homer with a color vocabulary in the same early stage of development which is found among many primitive races at the present day. Indeed, one might almost go so far as to say that Homer's terminology for color is in a stage of development which is on much the same level as that of Kiwai, and distinctly less developed than those of Murray Island and Mabuiag.

From the nature of the defects of language, it has been concluded that the color sense of both ancient and existing primitive races is in some way defective. The next stage in the inquiry is to investigate the color sense of some existing people, and this I have been able to do most satisfactorily in Murray Island. I tested about 150 natives of this island with Holmgren's wools for color-blindness, and failed to find one case in which there was any confusion between red and green, the

* Il., XXIV., 93.
† Il., XI., 24.
‡ Il., XXIII., 454.
§ Il., XI., 474.
¶ Il., X., 23.

common form of the defect in civilized countries. Since red-green blindness exists in about 4 per cent. of the male population of Europe, one may conclude that this form of defective color sense was either absent or was much rarer than with us. I also failed to find a case of color-blindness in Kiwai and Mabuiag and among the Australian aborigines, although I met with three well-marked cases of red-green blindness among eight natives of the Island of Lifu, in the Loyalty Group.

As regards other colors, however, the case was different; blue and green were constantly confused, and also blue and violet. Either owing to lack of interest or to some actual deficiency in color sense, there was a distinct tendency to confuse those colors for which their terminology was deficient. I have also found this tendency to confuse green and blue in several other races.

The behavior of the people in giving names to colors also pointed frequently in the same direction. I have already mentioned that in Mabuiag there was a great tendency to invent names for special colors; on one occasion a man, who seemed to have a special faculty in this direction, gave me as the name for a bright blue wool 'idiiridgamulnga,' which meant the color of the water in which mangrove shoots had been washed to make 'biiu,' an article of food. In this case there was a deliberate comparison of a bright blue with dirty water, and I frequently came across other instances of the kind, which seemed almost inexplicable, if blue were not to these natives a duller and a darker color than it is to us.

This view was confirmed by quantitative observations, made with Lovibond's Tintometer, which had been kindly lent to the expedition by Mr. Lovibond. When the native looked into this apparatus he saw two square patches of light, either of which could be colored in any intensity of red, yellow or blue by means of a delicately-graded series of glasses of those colors. The 'threshold' for each color was then determined by finding the most faintly colored glass which the native could recognize and name correctly. The results showed that the natives recognized a very faint red, a more pronounced yellow, and only recognized blue when of a considerable intensity. Similar observations made on a series of Englishmen showed greatest sensitiveness to yellow and somewhat less to red and blue. The results may be given more definitely in Mr. Lovibond's units of color; in Murray Island, red was perceived on the average at .18 units, yellow at .27 and blue at .60, while the average results for the English observers were .31, .20 and .36 respectively. These figures do not show anything approaching blue blindness, but they do show a relative insensitiveness to blue in the Murray Islander, as compared with the European. The former appears also to be relatively more sensitive to red.

Another method of investigating the subject quantitatively which I employed was to determine the distance at which small spots of different colors could be recognized. I found in Murray Island that natives could see a red spot 2 mm. square at over 20 meters, while a blue spot of the same size was confused with black at even 2 or 3 meters. Europeans, however, also recognized red at a much greater distance than blue, and I have not at present sufficient comparative data to enable me to say that there is any marked difference between the Murray Islander and the European in this respect.

These results do not show that these islanders are blue blind, but they do show fairly conclusively that they have a certain degree of insensitiveness to this color, as compared with a European. We have, in fact, a case in which deficiency in color language is associated with a corresponding defect in color sense.

On the question of the cause of this insensitiveness there is room for differences of opinion. It is, of course, possible that the insensitiveness may be apparent only and may be merely due to lack of interest, but there is, I think, little doubt that it depends on physiological conditions of some kind.

The Murray Islander differs from the Englishman in two important respects; he is more primitive and he is more pigmented, and his insensitiveness to blue may either be a function of his primitiveness or of his pigmentation. In other words, it is possible that his insensitiveness may depend on the lack of development of some physiological substance or mechanism, which acts as the basis of the sensation blue in ourselves, or it may only depend on the fact that the retina of the Papuan is more strongly pigmented than that of the European. There is some reason to think that this latter factor is the more important. We know that the macula lutea in the retina, which contains the region of most distinct vision, is pigmented, and that as a consequence of the reddish-yellow color of its pigment, blue and green rays are more strongly absorbed than red and yellow; we have reason to believe further that the macula of dark races is more pigmented than that of ourselves.

The consequence would be that, in dark races, blue and green would be more strongly absorbed, and consequently there would be a certain degree of insensitiveness to these colors, as compared with red and yellow. In the observations made with the tintometer, the patches of color were so small that only the macula would have been stimulated. The probability that the insensitiveness to blue depended, at any rate partially, on the pigmentation of the macula lutea is increased by the fact that the natives were able to recognize blue readily on the peripheral retina.

It would, of course, be wrong to make any wide generalization on the basis of these observations. One would not be justified in directly

applying the conclusions arrived at in the case of Murray Island to all existing races whose color nomenclature is defective, and still less so in applying them directly to the races of the past. Nevertheless, the fact remains that, in the only race which has been investigated with any degree of completeness,* the characteristic defect in color language has been found to be associated with a corresponding defect in color sense.

There are other sources from which evidence on the evolution of the color sense in man may be derived. It has already been mentioned that at an early stage in the controversy the evidence of ancient monuments was brought forward against the views of Gladstone and Geiger. It was pointed out that, long before the time of Homer, green and blue pigments were used in Egyptian sculpture and decorations. In the Berlin Museum there is a palette with seven depressions, which appear to have been used for seven colors, white, black, red, yellow, green, a bright blue and a dark color which may have been either blue or brown. Indeed, blue appears to have been the predominant color of Egyptian pottery, and blue and green beads have been found in the graves of the prehistoric Egyptian race. Green and blue appear also to have been used in the decoration of the ancient Assyrians and Chaldeans. Greek architecture has also been found in Thera, Tiryns and Mycenæ of a date earlier than that of Homer, in which the colors used include blue.

Mr. Bénaky, of Smyrna, has recently collected† the evidence derived from the coloration of ancient monuments, and believes that it decisively disproves the existence of any defect of color vision of the ancient Egyptians and Greeks. Two considerations must, however, be borne in mind when dealing with evidence of this kind. In the first place, it may be conceded that the monuments of the Egyptians show that these people had a perfectly developed color sense, and yet the color sense of the Greeks one thousand years or more later may have been defective. Just as we find different races at the present day in different stages of evolution as regards color, so it may have been three or four thousand years ago. The state of the color sense of the Egyptians has no direct bearing on that of the Greeks. It is a point of interest that the high development of the color sense in the ancient Egyptians, as shown by their decorations, appears to have been accompanied by a corresponding development of language, for it is stated‡ that in the ancient Egyptian language there were two words for green and one for blue.

* A full account of these investigations will be given in the reports of the Cambridge Expedition.

† 'Du sens chromatique dans l'antiquité.' Paris, 1897.

‡ See 'Kosmos,' Bd. I., s. 430; 1877.

The other consideration, to which, in my opinion, sufficient attention has not been paid, is whether the various colors are used appropriately. To prove the existence of a well-developed color sense from monuments, it is not enough to show that certain colors were used; it must be shown that they were used appropriately. Even in the case of Egyptian art, one reads of statues of human figures with blue hair, and in the case of early Greek art, the inappropriate use of one color, blue appears to have been very common.

I am informed by Mr. E. E. Sikes, to whom I am glad of this opportunity of expressing my thanks for much kind advice, that in the Acropolis at Athens, such examples of coloration are to be seen as a blue bull, a blue horse, a man with blue hair, beard and mustache, these probably dating from 600 B. C., certainly later than the time of Homer.* When such examples of eccentric coloration in blue are found associated with the defect in nomenclature for the same color, it is difficult to believe that the sense for this color can have been as highly developed in those times as it is among civilized races at the present day. The whole subject of the use of color in ancient monuments, in its bearing on color vision, requires a more thorough investigation than it has hitherto received.

Another line of objection to the views of Gladstone and Geiger, which has already been mentioned as having been taken up by Grant Allen, is derived from the high degree of development of the color sense in many of the lower animals, and especially in insects and birds. To many of those who have taken part in the controversy, this objection appears to have been regarded as conclusive. A well-developed color sense in any one branch of the animal kingdom does not, however, necessarily imply the existence of the same in other, even if higher, forms. We have many instances of the independent development of closely similar mechanisms in very widely separated branches of the animal kingdom, and there is nothing improbable in the view that this may have been so in the case of the color sense. If the color sense were found to be highly developed in mammals, the fact would naturally have a closer bearing on the color sense of man than has the presence of a similar development in birds. The evidence, however, of such development in mammals is very defective. Graber,† who has carried out the most comprehensive investigations of the color sense in different branches of the animal kingdom, obtained much less definite evidence from mammals than from other animals, and altogether failed to obtain evidence in the case of some species. Again, if the anthropoid apes were found to have a well-developed color sense, the fact would have

* See also Gardner, 'Handbook of Greek Sculpture,' p. 28.

† 'Grundlinien zur Erforschung des Helligkeits und Farbensinnes der Tiere.' Prag., 1884.

a still closer bearing on the condition of primitive man, but here again the scanty evidence is negative. The only experimental investigation with which I am acquainted is that made by Romanes* on the chimpanzee 'Sally' in the Zoological Gardens. After having successfully taught this animal to recognize numbers, Romanes proceeded to apply a similar method to teach her colors, but wholly without success, and he was obliged to conclude that the animal was probably color-blind. It may be objected that the brilliant coloration of the mandrill and other species points to the existence of a color sense in the primates, but little weight can be attached to such indirect evidence in the absence of experimental investigation.

Another subject which has some bearing on the question is that of the color sense of the human child. It is now a more or less accepted principle in biology that the history of the individual presents the same stages of development as have occurred in the history of the race. Darwin† was the first to point out that the power of distinguishing colors is a very late accomplishment in childhood; he found that his children were unable to name colors correctly at an age in which they knew the names of all familiar objects. This subject has since been the subject of much investigation, the most important work having been done by the late Professor Preyer‡ and by Garbini.§ Preyer made a very large number of investigations on one child, while Garbini has based his results upon the observations of no less than 600 children. Both agree in the conclusion that the child is unable to distinguish colors at all till towards the end of the second year, and they also agree that red is distinguished and named correctly at an earlier age than blue, although there is some difference of opinion as to the exact order of development of other colors. Garbini points out further that the power of distinguishing colors develops earlier than the power of naming colors, language appearing to lag behind sense. If any importance is to be attached to the bearing of the history of the child on the history of the race, the evidence from childhood is in favor of the view that the color sense of man is a comparatively recent acquirement.

Whatever room for difference of opinion there may be on the question of the evolution of the color sense, there can be no doubt that there has been an evolution of color language. The possibility that the course of this evolution has been determined by physiological conditions has been considered, but there can, I think, be little doubt that these have not been the only factors upon which the characteristic defects of language have depended. The deficiency in the sense for blue, which

* 'Proc. Zoolog. Soc.,' 1889; p. 316.

† 'Kosmos,' Bd. I., s. 376; 1877.

‡ 'Die Seele des Kindes.' Leipzig, 1884.

§ 'Arch. per l'Anthropologia e la Ethnologia,' Vol. XXIV., pp. 71 and 193; 1894.

I found in Torres Strait, is only partial and can not wholly account for the absence of a word for that color. Even to those with normal sensitiveness to blue, I think, there is no doubt that there is a closer resemblance between blue and black and between green and black than between red and black, and this difference in the degree of similarity between the different sensations of color and that of blackness may account in some measure for the difference in the definiteness of nomenclature.

It is a characteristic of the language of primitive races to have special names for every natural object, and often for very many individual parts of a natural object. If the savage has one name for one blue flower and another name for another, and so on, he will not require a name for the abstract quality of blueness. It is possible that he only begins to require names for colors when he begins to use pigments. If this be the case, it may help to explain the earlier development of names for red and yellow, for in many parts of the world pigments of these colors are by far the most common. In Torres Strait there were both red and yellow pigments, but no green pigment, and the nearest approach to a blue pigment was a slate-colored shale, and there appear to be many parts of the world where a blue pigment is wholly absent. Probably the most widely distributed blue pigment is indigo, and I have endeavored to ascertain whether those races which are familiar with indigo have a word for blue, but the evidence I have at present is too scanty to allow me to express an opinion on this point. It is probable, however, that the distribution of pigments has helped to determine the characteristic features of primitive color nomenclature, the greater frequency of red and yellow pigments being probably one of the factors which account for the more definite nomenclature for those colors.

Another factor, which may have been of importance, is the absence in the savage of an æsthetic interest in nature. The blue of the sky, the green and blue of the sea and the general green color of vegetation do not appear to interest him. It is, however, possible that the sky and sea do not interest the savage, or interest him less than the civilized man, because their colors are less brilliant than they are to us, and consequently this factor is not one on which much stress can be laid.

The widespread defect in the nomenclature for blue is rendered more striking by the fact that a name for red is universally present in primitive languages, while in many languages, as in that of Murray Island, various shades of red are not only discriminated, but also receive special names. In the experiments made in Torres Strait it seemed to me that this definiteness in the nomenclature for red was associated with a high degree of sensitiveness to this color, apparently

greater than that of the average European. I also found, both by observation of their clothing and by direct questioning, that red was the favorite color of these people. In reading accounts of primitive man, one can not help being struck by the great predominance of red in the decoration of their houses, weapons and implements. This predominance may partly be due to the striking nature of the color and also to the prevalence of red pigments, but it seems possible that it may also be connected with the fact that red is the color of blood. Many savage races appear to be in a state of constant warfare, and in the religious rites and ceremonies of nearly all primitive races blood pays a great part.

The suggestion may even be hazarded that the earliest use to which red pigments were put was to smear the body in the war-dance, to imitate the blood-stained victor,* or to replace blood in the various ceremonies of which it so often forms an essential feature. In his 'Legend of Perseus,'† Mr. Hartland has collected a number of instances in which it is perfectly obvious that vermilion or other red pigment has been used in the place of blood. Both in Murray Island and Mabuiag the chief words for red were derived from the name for blood, and this derivation is found in many languages, including our own. To whatever cause it may be due, there is no doubt that red is the most important color in the life of the savage, and it is natural that the predominant color should also be that which has the most definite name.‡

The main conclusions may be summed up as follows: The language used for color in ancient writings shows a characteristic defect, from which it has been concluded that the color sense of ancient races was also defective.

Existing primitive races agree in showing the same defect of color language as is found in ancient writings, and, in at least one such race, there has been found to be a corresponding defect in color sense, consisting in a certain degree of insensitiveness to those colors for which the nomenclature is defective.

Evidence, derived from ancient monuments and from the color vision of animals, which has been held to disprove the existence of any defect in the color senses of the ancients, appears to be inconclusive, and might, indeed, be held to support the views which have been derived from the study of language.

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* This custom appears to have persisted down to Roman times, in which the conqueror painted his body red when taking part in the triumphal procession.

† Vol. II., pp. 242, 264; notes, 342, 354-5.

‡ Since the above was written, the question of the predominance of red has been fully discussed by Havelock Ellis. (POPULAR SCIENCE MONTHLY, August and September, 1900.)

The observations made on the color vision of childhood may be regarded as indirect evidence that color vision has been a comparatively recent acquirement of the human race.

In addition to possible physiological conditions, there are certain other factors which may have taken part in the production of the characteristic features of primitive color language.

On the more special question of the color sense of Homer, I believe that Gladstone and Geiger went too far. The evidence seems to me to suggest one of two possibilities. It is possible that to the Greeks of the time of Homer green and blue were less definite, possibly duller and darker colors than they are to us. It is, however, possible that the language used by Homer was only a relic of an earlier defect of this kind, the defect of nomenclature persisting after the color sense had become completely developed, language lagging behind sense in the race, as it appears to do in the child. According to the latter view, the defective terminology of Homer would be a phenomenon of the same order as the absence of a word for blue in such languages as Welsh, Chinese and Hebrew at the present day. It would not necessarily show the actual existence of a defective color sense, but would suggest that at some earlier stage of culture there had been defective sensitiveness for certain colors.

The evidence derived from poetry and art must always be in some degree unsatisfactory, owing to the great part which convention plays in these productions of the human mind. Still, every convention must have had a starting point, and though, in some cases, it is possible that considerations of technique* may have originated the conventional use of color, it seems more probable that the predominance of red and deficiency of blue, both in the color language and in the decoration of the ancient Greeks, however conventional they may have become, nevertheless owe their origin to the special nature of the development of the color sense.

The subject of the evolution of the color sense in man is one which can only be settled by the convergence to one point of lines of investigation which are usually widely separated. The sciences of archæology, philology, psychology and physiology must all be called upon to contribute to the elucidation of this problem. I do not wish to do more than reopen the subject, and shall be contented if I have shown that the views of Gladstone and Geiger cannot be contemptuously dismissed as they were twenty years ago.

* As an instance of the origin of a convention in technique, Mr. Sikes has suggested to me the red figures on Greek vases. Early Greek vases were made of a reddish material, on which the figures were designed in black. At a later time, the vessels were black and the figures red, the conventional persistence of red decoration in this case having had its starting-point in the special nature of the material originally used in the manufacture of the vases.

A STUDY OF BRITISH GENIUS.

By HAVELOCK ELLIS.

V. CHILDHOOD AND YOUTH.

IF we consider the time of birth of our group of British persons of preeminent ability we find that April shows the largest number of births and January the fewest number. In passing from January to February there is a marked and sudden rise, so that when we consider the total births, according to the quarter of the year, the first, second and fourth quarters are fairly equal, but there is a decided deficiency in the third quarter. This is not quite the result which we find on considering the birth-rate among the ordinary population of England and Wales during the nineteenth century. Here the birth-rate during the first and second quarters agrees in being very high, while the third and fourth quarters invariably show a low rate. The discrepancy is in the fourth quarter, persons of preeminent ability being born during that quarter in unduly high proportion. In order to reach the time of conception, and so consider the possible significance of these facts, we must, of course, push these periods three months forward.*

The first significant fact we encounter in studying the life-histories of these eminent persons is the frequency with which they have shown marked constitutional delicacy in infancy and early life.† A group of at least five—Joanna Baillie, Hobbes, Keats, Newton, Charles Wesley—were seven months children, or, at all events, notably premature in birth; it is a group of very varied and preeminent ability. Not including the above (who were necessarily weakly), at least eight are noted as having been very weak at birth, and not expected to live; in several cases they were, on this account, baptized on the same day. In addition to these, fifty-five are described as being of very delicate health in infancy or childhood. Further, we are told of sixty-nine

* For a discussion of the normal phenomena, see H. Ellis, 'Studies in the Psychology of Sex,' 'The Phenomena of Sexual Periodicity.'

†Mr. A. H. Yoder ('Pedagogical Seminary,' October, 1894) stumbled across this fact in the course of his interesting study of the early life of a group of men of genius, but failed to realize its significance. He put it aside as due to a desire on the part of biographers to magnify the mental at the expense of the physical qualities of their subjects. There is no evidence whatever for this gratuitous assumption.

others that throughout life they suffered more or less from chronic ill-health, so that we may assume that in most cases their feeble constitutions were congenital and existed at birth. Thus, at the lowest estimate—for we may be certain that the national biographer has very frequently overlooked the point—137 of the 902 British men and women of preeminent intellectual ability (or 15 per cent.) were congenitally of notably feeble physical constitution.

Although it may fairly be assumed that this proportion, at least, of our eminent persons showed signs of physical inferiority at the beginning of life, it must not be assumed that in all cases such inferiority was marked throughout life. The reverse of this is notably the case in many instances. This is not indeed absolutely proved by longevity, frequently noted in such cases, for men of genius have sometimes lived to an advanced age, though all their lives suffering from feeble health. But there is a large group of cases (probably much larger than actually appears), in which the delicate infant develops into a youth or a man of quite exceptional physical health and vigor. Bruce, the traveler, is a typical example. Very delicate in early life, he developed into a man of huge proportions, athletic power and iron constitution. Jeremy Bentham, very weak and delicate in childhood, became healthy and robust and lived to eighty-four; Burke, weak and always ailing in early life, was tall and vigorous at twenty-seven; Constable, not expected to live at birth, became a strong and healthy boy; Dickens, a puny and sickly child, was full of strength and energy by the age of twelve; Galt, a delicate, sensitive child, developed Herculean proportions and energy; Hobbes, very weak in early life, went on gaining strength throughout life and died at eighty-one; Lord Stowell, with a very feeble constitution in early life, became robust and died at ninety-one. It would be easy to multiply examples, though the early feebleness of the future man of robust constitution must often have been forgotten or ignored, but it is probable that this course of development is not without significance. I have noted those cases in which one or both parents have died soon after the birth of their eminent child. One small, but eminent, group—Blackstone, Chatterton, Cowley, Newton, Adam Smith, Swift—had lost their fathers before birth. By the age of five at least fifty-five of these eminent persons had lost their fathers and thirty-one their mothers. By the age of ten at least eighty-eight had lost their fathers and fifty their mothers. In fourteen of these cases both parents were dead. So that over 14 per cent. had lost one or both parents by the age of ten. It is difficult to estimate the real extent of this tendency on account of the imperfect nature of the data, nor have I any data at hand for normal families. In New Zealand a useful enactment requires the ages of living children to be inserted in the parent's death certificate.

Full particulars are not given by the Registrar-General of New Zealand in any report in my possession, but it appears that at least 45 per cent. of New Zealand children whose fathers died under the age of sixty-five were under fifteen at the time. This, of course, does not tell us what proportion these children bear to the children of the same age whose fathers are living. In English reformatories, Douglas Morrison notes, as a very high proportion, that 33 per cent. of the children admitted under the age of sixteen had lost one or both parents.

The chief feature in the childhood of persons of eminent intellectual ability brought out by the present data is their precocity. This has indeed been emphasized by previous inquirers into the psychology of genius, but its prevalence is very clearly shown by the present investigation. It has certainly to be said that the definition of 'precocity' requires a little more careful consideration than it has sometimes received at the hands of those who have inquired into it, and that when we have carefully defined what we mean by 'precocity' it is its absence rather than its presence which ought to astonish us in men of genius.* Judging from the data before us, there are at least three courses open to a child who is destined eventually to display preeminent intellectual ability. He may (1) show extraordinary aptitude for acquiring the ordinary subjects of school study; he may (2), on the other hand, show only average, and even much less than average, aptitude for ordinary school studies, but be at the same time engrossed in following up his own preferred lines of study or thinking; he may, once more (3), be marked in early life solely by physical energy, by his activity in games or mischief, or even by his brutality, the physical energy being sooner or later transformed into intellectual energy. It is those of the first group, those who display an extraordinary aptitude for ordinary school learning, who create most astonishment and are chiefly referred to as proving the 'precocity' of genius. There can be no doubt whatever that even in the very highest genius such extraordinary aptitude at a very early age is not infrequently observed. It must also be said that it occurs in children who, after school or college life is over, or even earlier, display no independent intellectual energy whatever. It is probable that here we really have two classes of cases simulating uniformity. In one class we have an exquisitely organized and sensitive mental mechanism which assimilates whatever is presented to it, and with development ever seeks more complicated problems to grapple with. In the other class we merely have a sponge-like mental receptivity, without any corresponding degree of aptitude for intellectual organization, so that when the period of

* For a summary of investigations into the precocity of genius, see A. F. Chamberlain, 'The Child,' pp. 42-6.

mental receptivity is over no further development takes place. The second group, comprising those children who are mostly indifferent to ordinary school learning but are absorbed in their own lines of thought, certainly contains a very large number of individuals destined to attain intellectual eminence. They by no means impress people by their 'precocity'; Scott, occupied in building up romances, was a 'dunce'; Hume, the youthful thinker, was described by his mother as 'uncommon weak-minded.' Yet the individuals of this group are often in reality far more 'precocious,' further advanced along the line of their future activities, than the children of the first group. It is true that they may be divided into two classes, those who from the first have divined the line of their later advance, and those who, like the youthful Diderot, are only restlessly searching and exploring; but both alike have really entered on the path of their future progress. The third group, including those children who are only noted for their physical energy, is the smallest. In these cases some powerful external impression—a severe illness, an emotional shock, contact with some person of intellectual eminence—serves to divert the physical energy into mental channels. In those fields of eminence in which moral qualities and force of character count for much, such as statesmanship and generalship, this course of development seems to be a favorable one, but in more purely intellectual fields it scarcely seems to lead very often to the finest results. On the whole, it is evident that 'precocity' is not a very valuable or precise conception as applied to persons of intellectual eminence. The conception of physical precocity is fairly exact and definite. It indicates an earlier than average attainment of the ultimate growth and maturity. But we are by no means warranted in asserting that the man of intellectual ability reaches his full growth and maturity earlier than the average man. And even when as a child he is compared with other children, his marked superiority along certain lines may be apparently more than balanced by his apparent inferiority along other lines. It is no doubt true that, in a vague use of the word, genius is very often indeed 'precocious'; but it is evident that this statement is almost meaningless unless we use the word 'precocity' in a carefully defined manner. It would be better if we asserted that genius is in a large number of cases mentally abnormal from the first, and if we were to seek to inquire precisely wherein that mental abnormality consisted. With these preliminary remarks we may proceed to note the prevalence among British persons of genius of the undefined conditions commonly termed 'precocity.'

It is certainly very considerable. Although we have to make allowance for ignorance in a large proportion of cases, and for neglect to mention the fact in many more cases, the national biographers note that

223 of the 902 eminent persons in our list may in one sense or another be termed precocious, and only thirty-seven are mentioned as not precocious. Many of the latter belong to the second group, as defined above—those who are already absorbed in their own lines of mental activity—and are really just as 'precocious' as the others; thus Cardinal Wiseman as a boy was 'dull and stupid, always reading and thinking;' Byron showed no aptitude for school work, but was absorbed in romance, and Landor, though not regarded as precocious, was already preparing for his future literary career. In a small but interesting group of cases, which must be mentioned separately, the mental development is first retarded and then accelerated; thus Chatterton up to the age of 6½ was, said his mother, 'little better than an absolute fool,' then he fell in love with the illuminated capitals of an old folio, at seven was remarkable for brightness and at ten was writing poems; Goldsmith, again, was a stupid child, but before he could write legibly he was fond of poetry and rhyming, and a little later he was regarded as a clever boy, while Fanny Burney did not know her letters at eight, but at ten was writing stories and poems.

Probably the greatest prodigies of infant precocity among these eminent persons were Cowley, Sir W. R. Hamilton, Wren and Thomas Young, three of these, it will seem, being men of the first order of genius. Barry and Thirlwall were also notable prodigies, and it would be easy to name a large number of others whose youthful proficiency in learning was of extremely unusual character. While, however, this is undoubtedly the case, it scarcely appears that any actual achievements of note date from early youth. It is only in mathematics, and to some extent in poetry, that originality may be attained at an early age, but even then it is very rare (Newton and Keats are examples), and is not notable until adolescence is completed.

The very marked prevalence of an early bent towards those lines of achievement in which success is eventually to be won is indicated by the fact that in those fields in which such bent is most easily perceived it is most frequently found. It is marked among the musicians, and would doubtless be still more evident if it were not that our knowledge concerning British composers is very incomplete. It is specially notable in the case of artists. It is reported of not less than thirty-five (or in the proportion of over 50 per cent.) that in art they were 'precocious.'

A certain proportion of the eminent persons on our list have followed the third course of early development as defined above, that is to say, they have been merely noted for physical energy in youth. Sir Joseph Banks was very fond of play till fourteen, when he was suddenly struck by the beauty of a lane; Isaac Barrow was chiefly noted for fighting at school; Chalmers was full of physical activity,

but his intellect awoke late; Thomas Cromwell was a ruffian in youth; Thurlow, even at college, was idle and insubordinate; Murchison was a mischievous boy, full of animal spirits, and was not interested in science till the age of thirty-two; Perkins was reckless and drunken till his conversion. It can scarcely be said that any of these remarkable men, not even Barrow, achieved very great original distinction in purely intellectual fields. In order to go far, it is evidently desirable to start early.

The influence of education on men of genius is an interesting subject for investigation. It is, however, best studied by considering in detail the history of individual cases; generalized statements cannot be expected to throw much light on it. I have made no exact notes concerning the school education of the eminent persons at present under consideration; it is evident that as a rule they received the ordinary school education of children of their class, and very few were, on account of poverty or social class, shut out from school education. A small but notable proportion were educated at home, being debarred from school-life by feeble health; a few, also (like J. S. Mill), were specially educated by an intellectual father or mother.

The fact of university education has been very carefully noted by the national biographers, and it is possible to form a fairly exact notion of the proportion of eminent British men who have enjoyed this advantage. This proportion is decidedly large. The majority (53 per cent.) have, in fact, been at some university. Oxford stands easily at the head; 40 per cent. of those who have had a university education received it at Oxford, and only 33 per cent. at Cambridge. An interesting point is observed here; the respective influences of Oxford and Cambridge are due to geographical considerations; there is a kind of educational watershed between Oxford and Cambridge, running north and south, and so placed that Northamptonshire is on the eastern side. Cambridge drains the east coast, including the highly important East Anglian district and the greater part of Yorkshire, whilst Oxford drains the whole of the rest of England as well as Wales. This at once accounts both for the greater number of eminent men who have been at Oxford and for the special characteristics of the two universities, due to the districts that have fed them, the more literary character of Oxford, the more scientific character of Cambridge. The Scotch universities are responsible for 15 per cent. of our eminent men, Edinburgh being at the head, Glasgow and St. Andrews following at some little distance. Trinity College, Dublin, shows 3 per cent. The remaining 8 per cent. have studied at one or more foreign universities, sometimes in addition to study at a British university. Paris (the Sorbonne) stands at the head of the foreign universities, having attracted as many English students as all the other European univer-

sities put together. This is doubtless mainly due to the fact that Paris was the unquestioned intellectual center of Europe throughout the long period of the Middle Ages, though the intimate relations between England and France may also have had their influence. With the revival of learning Italian universities became attractive, and Padua long retained its preeminence as a center of medical study. During the seventeenth century the Dutch universities, Leyden and Utrecht, began to attract English students, and continued to do so to some extent throughout the greater part of the eighteenth century. It was not until the nineteenth century that English students sought out the German universities. Douai might perhaps have been included in the list as the chief substitute for university education for the eminent English Catholics who have appeared since the Reformation.*

While the fact of university education is easily ascertained, it is less easy to define its precise significance. The majority of our men of preeminent intellectual ability have been at a university; but it would be surprising were it otherwise, considering that the majority of these men belong to the class which in ordinary course receives a university education. It would be more to the point if we knew exactly what influence the universities had exerted, but on this our present investigation throws little light. In a considerable number of cases, at least, the university exerted no favorable influence whatever, the eminent man subsequently declaring that the years he spent there were the most unprofitable of his life; this was so even in the case of Gibbon, whose residence at Oxford might have been supposed to be very beneficial, for at the age of fourteen he had already been drawn toward the subject of his life-task. In a large number of cases, again, the eminent man left the university without a degree, and in not a few cases he was expelled. It is evident, however, on the whole, that university life has not been unfavorable to the development of intellectual ability, and that while our eminent men do not appear to have been usually subjected to any severe educational discipline, they have been in a good position to enjoy the best educational advantages of their land and time.

* It may be interesting to compare these results with those obtained by Mr. Maclean in his study of nineteenth century British men of ability. He found that among some 3,000 eminent men, 1,132, or 37 per cent., are recorded as having had an English, Scotch or Irish university education. Of these 1,132, 37 per cent. were at Oxford, 33 per cent. at Cambridge, 21 per cent. at Scotch universities, 7 per cent. at Dublin, and the small remainder were scattered among various modern institutions. It will be seen that university education plays a comparatively small part in this group. This may be in part due to the lower standard of eminence, but it may also be due to the wide dissemination of the sources of knowledge. In no previous century would so encyclopædic a thinker as Herbert Spencer have been able to ignore absolutely the advantages of university centers.

If this is not a very decisive result to reach, there is another less recognized method of educational development which occurs so frequently that I am disposed to attach very decided significance to it. I refer to residence in a foreign country during early life. The eminent persons under consideration have indeed spent a very large portion of their whole lives abroad, whether from inclination, duty or necessity (persecution or exile), and it might be interesting to note the average period of life spent by a British man of genius in his own country. I have not attempted to do this, but I have invariably noted the cases in which a lengthened stay abroad has occurred during the formative years of childhood or youth. I have seldom knowingly included any period of less than a year; in a few cases I have included lengthened stays abroad which were made about the age of thirty, but in these cases those periods of foreign residence exerted an unquestionable formative influence. I have excluded soldiers and sailors altogether, for in their case absence from England at a very early age has been an almost invariable and inevitable incident of their lives, and has not always been of a kind conducive to intellectual development. Nor have I included the very numerous cases in which transference from one part of the British Islands to another has sufficed to exert a stimulating influence of the greatest importance. With these exceptions, we find that as many as 322 of the eminent persons on our list (or about 40 per cent.) during early life, and in all but a few cases before the age of thirty, have spent abroad periods which range from about a year, and in very many cases have extended over seven years, up to extreme cases, like that of Caxton, who went to Bruges in early life and stayed there for thirty years; or Buchanan, who went to France at the age of fourteen and was abroad for nearly forty years. It is natural that France should be the country most frequently mentioned as the place of residence, but France is closely followed by other countries, and a familiarity with many lands, including even very remote and scarcely accessible countries, is often indicated. It may further be noted that this tendency to an association between high intellectual ability and early familiarity with foreign lands is by no means a comparatively recent tendency. It exists from the first; the earliest personage on our list, St. Patrick, was kidnapped in Scotland at the age of sixteen, and conveyed over to Ireland; it seems, indeed, that in the nineteenth century the tendency became less marked, in face of the average modern Englishman's hasty and unprofitable method of traveling. In any case, however, it is evident that there has been a very marked tendency among these men of preeminent ability to familiarize themselves in the most serious spirit with every aspect of nature and life. It is equally marked among the men of every group, among poets and statesmen, artists and divines. It is not least marked in the case of men of sci-

ence from the days of Ray onwards; if it had not been for the five years on the *Beagle* we should scarcely have had a Darwin, and Lyell's work was avowedly founded on his constant foreign tours. In a notable number of cases this element comes in at the earliest period of life, the eminent person having been born abroad and spent his childhood there. The presence of so large a number of our eminent men at a university may be in considerable measure merely the accident of their social position. The persistence with which men of the first order of intellect have sought out and studied unfamiliar aspects of life and nature, or have profited by such aspects when presented by circumstances, indicates a more active and personal factor in the evolution of genius.

THE FROG AS PARENT.

By Professor E. A. ANDREWS,
JOHNS HOPKINS UNIVERSITY.

IN the life of a common frog or toad we seem to find none of that altruistic solicitude for the welfare of the helpless younger members of society, that we so fondly attribute as guide in many of our own actions. In clamorous spring reunions these cold-blooded creatures deposit their eggs in the water and go their way in search of food—not knowing whether some or many of the eggs will run a normal course through tadpole or pollywog states to tailless adults, or fall a prey to hungry ducks, or more insatiable naturalists in search of 'material' for study.

The naturalists' belief that these Amphibia are closely akin to fish in many ways is borne out in their breeding habits; for, like fish, they have more or less complex 'instincts' that lead the males and females together at the laying season, and then, like fish, they separate till the next period of egg-laying. The eggs, discharged in the water, are fertilized outside the body, and undergo a process of cleavage or cell-multiplication, thus gradually differentiating into active larvæ or tadpoles without any care from the parents. The tadpole leads its own independent fish-like life for months or years, till—if not destroyed—the critical period of transformation arrives. This passed, the young frog or toad has only its instincts to guide it in learning the new life and nothing to learn from its parents—unless perchance they may be near enough to endeavor to swallow it alive.

Yet even here we might fancy some thought for the morrow of the species—the eggs are generally laid in the right place—according to the kind of frog or toad—to have enough water and not too many enemies for the young, while the protecting jelly mass about the eggs is often rather carefully fastened to plants or sticks, thus keeping them near the surface of the water and in optimum conditions for hatching.

But this is not clear until we see some of the extremes to which such prevision for the next generation is carried in certain members of this group. Just as amongst fish there are a few with most remarkable habits—the male stickleback watching and protecting the eggs in his carefully made nest—so, if we look far enough, we find frogs and toads that show most exemplary solicitude for the young. In Europe, Asia, Africa and in South America such curious life-histories are more or less common.

In most such cases the peculiar habit of the parent seems to be associated with an unusual character and development of the eggs. In the common species that have many small eggs, these are left by the parent to develop slowly in the water, where they gradually assume a frog-like character. Whereas species having few and large eggs protect these in some manner until they rapidly turn into frogs with little or none of the aquatic youth we are so used to regard as a *sine qua non* for a frog.

We need go no further than the island of Jamaica for examples of the protected eggs. For there, where everything has to compete strenuously for light and air, the trees themselves support dense populations of plants and these harbor animals of various sorts—amongst them, frogs. One kind of frog in Jamaica lays its eggs in the water that accumulates at the bases of the leaves of Bromelias growing high up on tree trunks, and here the tadpoles have their brief existence.

FIG. 1.

FIG. 2.

Another frog abandons even this semblance of aquatic life, laying a few very large eggs under stones and 'trash' on the ground, where they may even be many miles distant from the water—and the young develop into small frogs that hatch from the egg without having known what it is to be a tadpole. Stevenson's fable admits of literal application here.

'Be ashamed of yourself,' said the frog. 'When I was a tadpole I had no tail.' 'Just what I thought,' said the tadpole; 'you never were a tadpole.'

In this frog, however, there is within the egg a stage when the young is active and has a tadpole form, lacking chiefly the medium in which to express its tadpole possibilities. Not being able to swim with its tail, it yet puts this to good use, for it is richly supplied with blood-vessels and can serve as a breathing organ.

In the Solomon Islands there is another frog (*Rana opisthodon*) which lays large eggs, 6-10 mm. thick, on moist ground and not in

the water; and the young remain within the egg until they are complete frogs in shape. While passing through so much of their life-history within the egg shell, the young manage to breathe, not by their tails, but by special folds of skin that grow out on either side of the belly, in rows, as shown in Fig. 1. The young frog also makes a temporary contrivance for breaking through the egg shell, something like the horn on the beak of a hatching chick or the protuberance used by many reptiles for the same purpose. This peculiar little organ in the frog is shown in Fig. 1 and again in Fig. 2, where it adds a decided retroussé element to a not too intellectual countenance.

We might place frogs in three groups: those that are simply layers, those that are nest-makers, and those that are nurses.*

As a nest builder we may reckon the *Cystignathus mystaceus* of Brazil. This frog makes a hole about as big as a teacup under stones or decayed logs near enough to puddles of water to be covered by water when the pond rises after heavy rains. In this nest the yellow eggs are laid in a mass of thick, white foam, very like beaten white of egg in appearance. The eggs hatch into tailed tadpoles, and, when the water rises over the nest, these young swim off like our common tadpoles. They differ, however, in being able to overtide dry seasons. When the pond dries up and common tadpoles would die, these peculiar creatures gather under boards or logs and there keep moist—apparently by the aid of an unusual amount of material secreted by their skins. Evidently the habits of this frog are nicely adjusted to the climatic conditions under which it lives.

A tree-frog of West Africa *(Chiromantis rufescens)* lays its eggs in leaves of trees in a mass of foamy material that, on drying, hardens on the outside, but becomes liquid within, and so lets the tadpoles swim about for a while till a rain washes them off the tree into the water. While living the short part of its tadpole stage in the nest made by the mother for it, the tadpole has gills such as our common tadpoles breathe with, as well as a tail to swim with. In this aerial existence the young have the protection not only of the surrounding foam, but often of leaves that are sometimes stuck to it. This perfecting of the nest by the use of leaves to envelop the foam mass becomes the rule in two sorts of frog in Brazil *(Phyllomedusa Jheringii* and *Hyla nebulosa)*. The former puts its big white eggs into a mass 40-50 mm. long and 15-20 wide, enveloped by two or three leaves, sometimes willow tree leaves, in such a way that they make a tight case open at one end. The young seem to be so fitted for this peculiar wet-ham-

* The remarkable life histories not in the first group have recently been brought together by R. Wiedersheim, from whose papers in the 'Biologisches Centralblatt' most of the facts and illustrations used in this article are taken.

mock existence that it is doubtful if they need to fall off into the water; at all events, some tadpoles of *Hyla nebulosa* taken out of this nest and put into water, died in a few hours from lack of breath, being unable to live without the peculiar air supply they were used to. However, the larvæ of another frog *(Phyllomedusa hypochondrialis)* are set loose from the nest when the rain softens it and do fall into the water to continue their tadpole life. This species occurs in Paraguay, and makes use of the leaves of trees near the water. The male rides on the back of the female, while both bend in the edges of a single leaf till it makes a funnel. In this the eggs are laid and fertilized. The jelly surrounding them holds the leaf in place till the tadpoles hatch and are ready for the rain to forward them to their new destination.

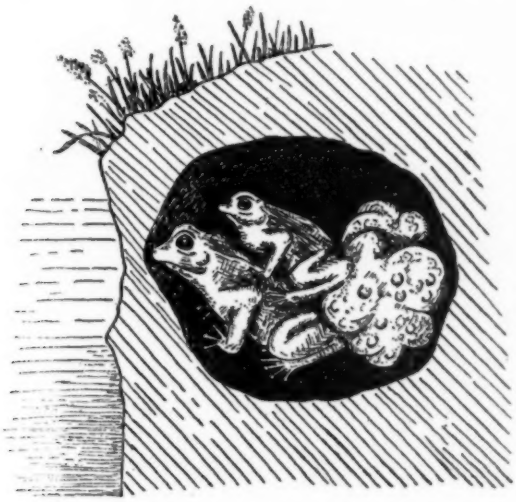

Fig. 3.

In Japan there is also a nest-making frog *(Rhacoporus Schlegeli)* which is said to lay its eggs sometimes amongst leaves on bushes or trees. However, its usual habit is to make a nest in the ground as indicated in Fig. 3. Awakening from their winter sleep, the frogs crawl along the edges of rice fields and swamps and dig out holes above the water level. The female carries the much smaller male, and both become buried in a hole 6-9 cm. wide and 10-15 cm. above the surface of the water. This nest cavity is smoothed inside by the movements of the female and is then, in the night, supplied with a ball of white matter full of air-bubbles. This is tough and elastic and 6-7 cm. thick. This mass is to supply moisture and air for the young. It emerges from the cloaca along with the eggs, and is then kneaded thoroughly by remarkable movements of the feet of the female.

Stretching out and closing the toes, she mixes the sticky mass with air and breaks the big bubbles up into smaller and smaller foam. Similar movements of the feet of the male drive the mass backward and leave the eggs more free for the fertilization that follows. When the eggs have been fertilized and provided with a protecting and aerating mass, the parents break out from the nest and take up their life amongst the trees. The foam mass meanwhile gradually becomes liquid, and flowing out through the hole the parents left on leaving the nest, carries the young into the outside water.

Very different is the nest made by another tree-frog in Brazil. The quaint, beaver-like activities of this creature *(Hyla faber)* are described by one who observed them in his own garden. On a moonlight night one may see a slight movement of the water as if something were moving under it. Then a little mud rises, shoved up by a tree-frog—but only the hands of this are visible. It dives down and again brings up mud;

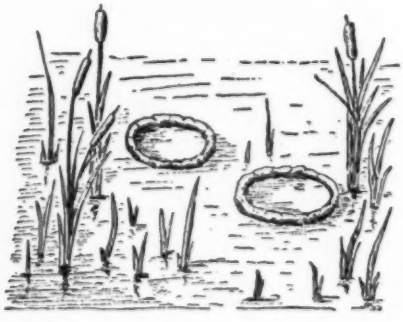

FIG. 4.

gradually the accumulated mud seems a little wall, and eventually it rises 10 cm. above the water and extends as a ring a foot in diameter. Such atolls of mud are shown in Fig. 4. They form little circular dikes of mud elevated above the general expanse of water. The making of them is by no means a matter of chance. The frog—and it is the female that labors, in full enjoyment of her 'rights,' while the male rides passively—uses her hands to compress and to smooth the inside of the wall in a most remarkable way. The top also of the miniature fortress is carefully *manipulated*, the frog crawling out of the water to make all the structure solid and smooth, all but the outer escarpment, which is left rough.

The frog makes the bottom of the crater-like cavity, under water, smooth by gliding along it on its belly, and also by spreading out its hands over it. During all this work the frogs make no sound, though near at hand isolated males may be heard calling their mates.

In this circular nest the spawn is deposited, but not till four or

five days, as a rule, after the nest is completed; there is a period of rest between the nest-making (which in one case required two successive nights) and the egg-laying. The young hatch out as tadpoles and continue to live in the narrow circle of home till the wall be broken down by time and weather to set them free in the world.

It is the habit of all these nest-makers to put their eggs into more or less imperfect nests and then go off and leave them to their fate, the nest, no doubt, increasing the chances of the young passing safely through the earliest stages of infancy—which we all know is a critical period for man or fish. Some other frogs have quite a different habit; carrying their eggs about with them, and so giving them the benefit, if not of actual defense against enemies, at least of passive protection, in that the eggs thus have the same conditions of moisture and concealment which they, the adults, need and obtain for themselves. Such frogs we have called 'nurses.'

FIG. 5.

FIG. 6.

Of these nurses the most often mentioned is the so-called 'obstetrical toad' found in Switzerland, France and western parts of Germany. As shown in Fig. 5, the eggs are carried about attached to a band, which is wrapped about the legs of its parent, but the parent who thus carries the offspring about in the moist grass as it seeks food in the evening is not, as one might expect, the mother, but the father toad.

When the eggs are laid and fertilized, the male takes up his burden and carries it till the young are ready to hatch, when he goes to the water and lets the brood escape into the proper element. What leads him there at the right time remains still to be found out. How he comes to assume this care is also not clear; according to some accounts the male, when upon the back of the female, seizes the egg-string first with the right, then with the left foot, and wraps it in figure of eight loops about its own legs. Others say that the male sits behind the female, with its back turned toward her, and as the eggs emerge, the male seizes them between his ankles and, throwing himself now on his back and now on his belly, turns over and over until the egg-string is all drawn out and wrapped about his legs; hence the name *Alytes obstet-*

ricans. Having taken the eggs, however this may be done, the frog emits a clear musical sound and goes hunting its own food, thinking, we may suppose, as little of its offspring as do our own common toads and frogs. The young require a long time to bring them to the hatching stage, and have also an unusually large and peculiar gill on each side.

The tree-frogs of the tropics furnish examples of egg-carrying habit as well as of nest-building. Thus in Ceylon a tree-frog *(Rhacophorus reticulatus)* carries its eggs in a cake-shaped cluster of about twenty firmly fixed to its belly, as indicated in Fig. 6. This time it is not the male, but the female, that aids the coming race by giving it transportation and protection. Probably, however, it is the male and not the female of a frog of the Seychell Islands *(Anthroleptes Seychellensis)* that carries about its young on its back. This is a most complex case, for the eggs are laid upon moist earth or rotten logs and kept moist by the body of the frog until they hatch; they have large tails,

FIG. 7.

FIG. 8.

and even the beginning of hind legs. Then the youngsters get up on the back of their parent and stick there till their development is complete. The peculiar little tadpoles have great power of adhesion, and can stick to the sides of a glass dish as they do to their parent's back (Fig. 7). Another such case occurs in Trinidad and in Venezuela. When the ponds dry up the young tadpoles of the frog *Phyllobates trinitates,* which are as yet without legs, though they have tails, stick themselves firmly to the back of the male frog (whether it is their father or the father of some other tadpoles does not appear), and in this way are carried 'pick-a-back' to some larger pond. Similar habits have been observed in the frogs *Dendrobates trivittatus* and *Dendrobates braccatus.*

Again, a frog *(Hylodes liniatus)* of Dutch Guiana is found with its tadpoles attached to its back, as seen in Fig. 8. The young, from a dozen to twenty, are attached, as shown, with their heads turned towards the middle of the mother's back and do not fall off, even when she leaps rapidly away. Thus the mother, and not the

father, carries the young with her. In the Brazilian tree-frog *(Hyla Goeldii)*, it is again the mother who bears the young with her. The eggs are very large and whitish and crowded together into a rounded mass on the back of the female, as represented in Fig. 9. While all the other frogs as yet mentioned seem to have no special organ or apparatus for holding the eggs or tadpoles as they carry them about with them, this Brazilian frog is provided with a growth of skin on its back to form a wall all around the eggs so that they lie in a spoon-like depression. The knowledge of such a change in the skin of the back for egg-carrying may make us more ready to receive the accounts of the Surrinam toad described by Mlle. Merrain in 1705. When, in 1725, the Dutchman Ruysch described the remarkable pits for carrying young which this creature has upon its back, the account met with natural skepticism, but at the present day reiterated observations place

FIG. 9.

FIG. 10.

the main facts beyond doubt. The female of this toad *(Pipa dorsigera)*, as seen in Fig. 10, bears its young upon its back, each in a separate case, like so many papooses.

The cases are made at the breeding season, and before that the two sexes look alike. How the eggs get into these special receptacles is still an unanswered question, though the male may be a factor in the case; at all events, when the male goes away after being some twenty-four hours on the back of the female, the spawn is found on the back of the female, where the eggs gradually sink down into circular pits, that are hollowed out in the skin, and are 10-15 mm. deep. When an egg has sunk down into one of these pits, a thick, leathery or horny roof forms over it, and thus shuts it out from the external world.

These roofs are 5-6 mm. thick, and have a dark color unlike the rest of the back. Whether they, like the rest of the chamber about the egg, are formed from the skin, or whether they may be modified rem-

nants of the mass laid with the egg, is as yet undecided. The part of the skin of the back not taken up by these pits rises up in small papillæ, and thus each pit is closely surrounded by a ring of papillæ. From 40-114 pits are formed, and 60-70 young are developed.

Each egg thus develops inside a diminutive womb-like chamber, on the back of the mother, but as yet we do not know whether the mother supplies any nutriment to the young while it is in this protecting chamber; the arrangement of lymph and blood vessels in the skin of the mother and the organization of the young, however, raise the question whether this may not be the case. In each pit the young tadpole lies with its back toward the roof and its belly downwards. For awhile it has a large yolk-bag, or enlargement of its belly, full of nutriment and richly supplied with blood vessels; also a tail. This tail is very large, and seems to be of no use, unless it may function as a breathing organ, as in the frog of Guadaloupe, mentioned above. Another peculiarity of these favored tadpoles is that they obtain their

FIG. 11.

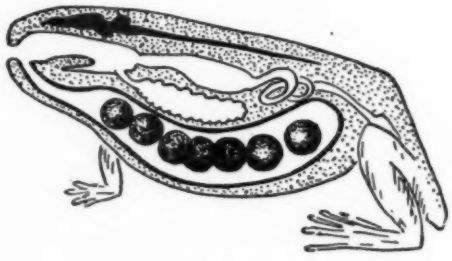

FIG. 12.

front legs at a very early period, before their gills grow out; and thus, for a long time, appear as four-legged creatures, with most imposing tails, as represented in Fig. 11.

In this condition they break off the roofs of their little houses and each, like a baby kangaroo from its mother's pouch, peers out into the world with goggle eyes and ready hands. For nearly three months (eighty-two days) the mother is burdened like Sindbad, till the young toads jump out of their cradles and go free to shift for themselves.

Every Surrinam toad is thus launched upon its individual voyage of contest for food as a complete but small toad, and, though it had the outward symbols of tadpole life—gills and a tail—it never lived a tadpole life, with its dangers from the drying of ponds, and the chances of being swallowed alive as so many tadpoles are. Our common tadpoles may, from one point of view, be regarded as chiefly feeding phases, like the caterpillar that eats and eats to pass through the inactive chrysalis stage to the complete butterfly life. Tadpoles are phases of the frogs' lives, when almost anything can be eaten, and when there

is but little perfection of the senses as compared with the future adult stage. The experience gained as tadpole would seem to be of very little direct use to the frog when it begins its new life; it is chiefly the gain in material, the results of feeding, that makes the frog the better for its tadpole life. In the Surrinam toad this gain in size is provided for by the mother, who takes all labor off the shoulders of her offspring till they are toads like herself. Is there not an analogy between such habits and our own attitude towards the next generation? The child of the savage, or of the more unfortunate classes in 'civilized' communities, is put to getting its own livelihood at the earliest possible age; the favored child of the few is protected by the parental roof and fed with even university pabulum till nearly arrived at adult structure.

But the Surrinam toad is not the only one that is built mammal-like, to carry its young within its own body; the group of pouched or marsupial frogs of Venezuela have an even stranger contrivance for this purpose. Those who are fortunate enough to have access to a copy of Professor Davenport's profusely illustrated little volume, 'Introduction to Zoology,' will find a very attractive figure of one of these 'brooding tree-frogs,' taken from a water-color painting at Harvard College. On the middle of its back, above the loins, is a very large opening leading into the interior of the animal. This is the opening of a large brood-chamber. In one frog *(Nototrema oviferum)* this chamber continues forward on each side as two, even larger, chambers that reach almost to the head. The middle chamber is on the back, while the side chambers extend not only over the back, but down on the side, so as almost to meet one another across the belly. All these chambers lie just beneath the skin and are not deep, but flat, though they displace the viscera.

The walls of the chambers are very thick and vascular, except near the external opening, where the wall is of the same nature as the skin. The skin, in fact, seems to have grown in to line these chambers, but has been much changed in its character in those parts of the chambers that are remote from the openings. It is not known how this big bag grows over the body, nor whether it is always there, or only developed at the breeding season. These chambers are found in the female, and in some unknown way the eggs are transferred from the ovary into the pouches. As there is no internal opening to the pouch, the eggs must be laid as usual and then put upon the back, and so into the external opening of the brood pouch. Possibly the male aids in this function.

The eggs of this species are exceedingly large, being 1 cm. in diameter, more than eight times the bulk of a common frog's egg, and are also but few in number. In one case there were only four eggs in the outer, middle, chamber and eleven others in the two side chambers—fifteen eggs in all.

The young that develop from these comparatively large eggs inside this peculiar skin-bag are remarkable enough to satisfy the ideals of so bizarre a parent. Like the young Surrinam toad, these get their front legs at a very early period, and at an early period are also found without the adhesive organs and horny jaws that seem so essential to all common tadpoles. But their chief departure from received tadpole style is the phenomenal character of the gills. These are large, bell-shaped, flower-like membranes that envelop the tadpole like a mantle and, coming between it and the walls of the mother's pouch, may serve as a means of getting oxygen and possibly food from the mother, for the gills are richly supplied with blood-vessels, and the walls of the mother's pouch are also vascular, giving the anatomical conditions for interchange such as takes place in a mammal's placenta. Each of these two gills seems to have been made by the fusing of two specialized gills, and each retains two stalks. Eventually these big gills are probably lost and replaced by inside gills, just as in common tadpoles the outside gills are always followed by inside gills. Whether the mother goes into the water and lets the young escape where they can use their gills, or whether she keeps them at home till they have lost these youthful structures and can 'come out' in budding maturity, is not known, in this case. But in *Nonotrema marsupiatum* and *Nototrema plumbeum* the young are set free into the water when they are still tadpoles.

The way in which such a capacious pocket on the back can have come about is perhaps indicated by the state of things in *Nototrema pygmæum*. The brood pouch is here small and slit-like, and when the young are ready to leave it they press and wriggle till the pouch is torn open, from the external opening forwards. There are only four to seven young that can come forth in this partially Cæsarian way, and their appearance seems to have been prearranged by the way in which the pouch is made. Two folds of the skin grow up to meet one another along the back, and when they fuse they leave a sort of seam, which is also the line along which the pouch ruptures to let the young out. The pouch of this tree-frog is thus to some degree intermediate between the simple cup on the back of *Hyla Goeldii*, not well shown in Fig. 9, and the more perfect sac of the other pouched frogs described above, and may indicate the lines along which structures and habits like those of *Hyla Goeldii* could have been evolved in those of *Nototrema oviferum*. On the other hand, the small size of this frog and the large size of its eggs make it both impossible to get the eggs into the usual external opening of the pouch and impossible for the big larvæ to escape through it; hence it may be that the pouch grows up as folds after the eggs are laid on the mother's back, and that these folds remain easy of separation to allow the young to escape, all independent

of any mode of development of the pouches of other marsupial frogs. These strange skin pits and bags of the Surrinam toads and the Venezuelan frogs are both an aid to the young and an inconvenience to the parent, and it seems in keeping with our general experience that it is the female that has these special organs and the female that suffers the dangers that go with the prolonged care of the offspring. In both respects, however, with regard both to the phenomenal nature of the breeding organs and in the amount of personal sacrifice, this female is outdone by the male of a little frog of Chili.

This frog is not much more than an inch long, and was first found by Darwin on the voyage of the 'Beagle.' In some unknown way the large eggs get into the mouth of the male and are carried a long time inside a huge sac that opens only into the front part of the mouth. In this pouch the young develop their legs and small tails. It is probable that they remain protected within the male till they are complete lung-breathing frogs and then get out of his mouth and escape. Why he does not eat them is a question that might naturally occur to one knowing only our common frogs.

The brood-sac of this male extends over the throat and belly, back to the loins and up on each side nearly to the backbone. The eggs and young that are found in it are from five to fifteen in number, and lie scattered about in the capacious chamber. The general anatomical relations of this sac are shown in the rude diagram, Fig. 12. This represents some of the organs that would be seen on cutting the frog into halves, lengthwise. The brain and spinal cord along the back are shown in black. Below this are the mouth, stomach and intestines. On the floor of the mouth is an elevated region, the tongue; behind this is the opening to an irregular cavity, one of the lungs. In front of the tongue is the opening to a very large sac, the brood-sac, in which the eggs are represented as large balls.

A bag of this size necessarily causes the skin of the throat to bulge out and also presses upon the internal organs. It is found that even the bones of the shoulder girdle and chest are modified in connection with this remarkable organ, and that the stomach, liver and intestines may be pressed out of place, so that feeding must be difficult. In some cases the digestive organs are said to be so impaired as to be of no use, while in other cases the brood-sac is of much less extent and would seem not to interfere seriously with feeding and digestion.

The brood-sac lies free under the skin, except in certain regions of the throat, where it is fastened to the skin. The lining of this sac is a continuation of the lining of the mouth, in fact, the sac is but an enormous side pouch from the mouth. In looking for any similar organ in common frogs, we find the single or paired resonance chambers that open into the mouth and serve to give volume to the voice. These

chambers are specially large in the male and most used in the breeding season. This Venezuelan frog, *Rhinoderma Darwinii*, seems to have only an enormous development of this resonance chamber converted to the singular purpose of harboring the young. As far as yet known, this frog leads the van of progress from the selfishness of the common frog to the altruism of the few; but there may remain to be discovered in tropical regions other frogs with structures and habits even more advantageous to the race and inconvenient to the individual.

Granting that all the above accounts of the breeding habits of frogs are reliable, they yet leave many details unknown. Very much remains to be found out before we can know the complete life histories of these remarkable creatures. Till we have a fuller knowledge, any attempt at explanation of the breeding habits and structures of these frogs would seem to be necessarily of a provisional nature.

Though it is difficult to describe these frogs without ascribing to them a far-seeing intelligence, the zoologist of to-day knows little ground for such assumption. Still less does he see in such examples of protection for the good of the race any direct acts of the Deity. He commonly interprets them as the results of the working of natural selection; and granting the potency of this means of evolution, the application to the above life-histories seems not difficult.

But it has been said that science is not concerned with the why, but only with the question, 'What is it precisely that does happen?' Shall we not work for more complete knowledge of the facts in the hope of a clearer view of the interconnection of organisms and environment?

May not our present attempts to understand such problems seem, in the future, as unscientific as does at present the fancy of the Japanese poet, who, centuries since, wrote:

"With hands resting on the ground, reverentially you repeat your poem, O Frog."

RECENT PHYSIOLOGY.

By Professor G. N. STEWART.

EVERY year a mass of original work in physiology, covering from ten to fifteen thousand pages, for the most part of formidable size and closeness of print, is collected in the various special journals of the science, or mingled with kindred, though miscellaneous, dust in the transactions of learned societies, or decently buried at the public expense in government bulletins and official reports. Those four hundred square yards of printed matter embrace, on the average, more than five hundred papers in German, English, French and Italian, without reckoning stray messages in less familiar tongues, such as Russian, Polish, Dutch, Spanish, the Scandinavian languages, the dog Latin of graduation theses, and even, it may be Japanese, Arabic and modern Greek. The great majority of these communications either contain new facts or are directed, often with notable acuteness, to the unfolding of new relations between facts previously established. It is obvious that no survey of recent physiology which is possible within the space at our disposal could pretend to exhaust the contents of its crowded archives even for a single year. I shall try rather to trace the main tendencies, while incidentally mentioning some of the outstanding achievements of recent physiological discussion and research, than to enter in any detail into the results of particular investigations.

Foremost among these tendencies is the study of the structure and functions, and especially the chemical and physico-chemical relations of the individual cell, in which, as has been well said by Bunge, in his brilliant Lectures on Physiological Chemistry, lies ever the riddle of life. While the mode of action of the complex physiological mechanisms, built up by the grouping and chaining together of cells of the same or of different kinds, deserves and has attracted the most assiduous attention, it has become more and more apparent that, as we push our enquiries back, we are always, sooner or later, arrested at the boundary of the cell. We attempt, for example, to explain the mechanism by which the circulation of the blood is maintained and regulated, and up to a certain point we succeed tolerably well. We recognize as the central factor the rhythmically contracting heart which forces the blood through the branching arteries into the netted labyrinth of the capillaries, whence it is again conveyed to the heart by the veins, and thus completes its destined round. We know that the rate and force of the heart-beat and the caliber of the blood vessels are controlled by efferent nerves carrying impulses down to them from centers situated in the medulla oblongata, the portion of the central nervous

system that serves to join the spinal cord to the brain. We are further aware that those centers are in touch with all parts of the body by afferent nerves, along which impulses are continually streaming to the centers. It is thoroughly established that the activity with which the centers discharge impulses along the efferent nerves to the heart and the vessels is modified by the arrival of afferent impulses. And it is fairly well understood how, by the action of this craftily balanced apparatus of nerve-fibers and nerve-centers, the supply of blood to the various tissues is adjusted to their ever-changing needs. But when we ask ourselves what happens in one of the nerve-cells which compose the nervous centers when it discharges an impulse? what that impulse which flies at the rate of a hundred miles an hour along the nerve-fiber really is? what is the precise nature of the actions which it arouses or represses in the muscular fibers of the heart or of the arteries when, in the twinkling of an eye, it impinges upon them? we have to answer that we do not know. We are in exactly the same position with regard to the voluntary contraction of the striped or skeletal muscles by means of which the ordinary movements of the body are executed. The nerve cells in which the impulses originate have been located with considerable precision in the so-called motor region of the brain, which comprises the middle portion of the superficial gray matter of each hemisphere. The tracts of nerve-fibers along which those impulses pass to the muscles have been mapped out. The influence of temperature, tension and other conditions on the muscular contraction has been investigated in great detail. But we are again almost completely in the dark as to the actual nature and course of the events that take place within the envelopes of the nerve-cell, the nerve-fiber and the muscular fiber when a muscle contracts in obedience to the will.

One or two promising clues there are, and these are being vigorously followed. Whenever a nerve or a muscle (or, indeed, for that part, a gland, although the phenomena are best seen in muscle and nerve) enters into a condition of physiological activity, an electrical change is set up in the excited part. In muscle, although not as yet in nerve, certain chemical, thermal and optical changes can also be demonstrated. It is obvious that the study of such phenomena, and especially their quantitative study, under as many different conditions as possible, is essential to the solution of our problem. Accordingly, data of this kind, which, it may be hoped, will some day become the basis of a great generalization, are being diligently gathered. Among the most important of recent contributions to the subject is an elaborate investigation of the electrical changes which accompany muscular contraction by Sir John Burdon Sanderson. By photographing the movements of the mercury in a capillary electrometer connected with the

muscle he has obtained a great series of marvelously beautiful records. Gotch and his pupils, using a similar arrangement, have been able to record the electrical changes in active nerves, even when stimulated by rapidly recurring shocks from an induction coil. It may surprise those who have not followed the progress of technique in the biological sciences to learn the extent to which photography is now applied in physiological research. Pictures of even such feeble vibrations as those which give rise to the sounds of the heart may be obtained by connecting a microphone placed near the chest and the primary coil of an induction machine in the same circuit, and photographing the movements of a capillary electrometer connected with the secondary. Exquisite photographs of the electrical variations occurring in the human heart at each beat, first demonstrated by Waller, have been recently published by Einthoven and Lint.

Loeb, working from another direction, has studied the effect of the ions contained in solutions of certain simple salts on rhythmical contraction in general, and particularly on the rhythmical contraction of the heart. He starts with the observation that a striped muscle in a solution of sodium chloride of a certain strength carries out rhythmical contractions which may last 24 to 48 hours. Salts of lime and of potassium hinder the contractions. Nevertheless the muscle remains longer alive when a small amount of calcium or potassium chloride is added to the sodium chloride solution. He explains the seeming paradox by the hypothesis that the sodium ions are the real stimulus for the rhythmical contractions, but yet exert on the muscle a poisonous influence, which is counteracted by the calcium and potassium ions. He finds support for the idea that the sodium ions are actually poisonous to the living substance in the fact that *Fundulus heteroclitus*—a small marine fish with so marvelous a range of adaptation to its environment that it will live, on the one hand, in sea-water to which sodium chloride has been added to the amount of five per cent., and, on the other hand, in fresh and even in distilled water—will not live in pure sodium chloride solutions of about the same strength as sea-water, but will survive in sodium chloride solutions even twice as strong if a little chloride of calcium or of potassium be added. According to Lingle, one of the pupils of Loeb, sodium ions, while acting as the normal stimulus to the discharge of rhythmical contractions by the heart muscle of the turtle, exert upon it, in the absence of calcium and potassium ions, the same deleterious influence as upon striped muscle, a fact also demonstrated by Ringer and others for the heart of the frog. These are the experiments which that eminent contributor to the gayety of nations, the scientific newspaper reporter, has recently travestied under the caption, 'Discovery of the Elixir of Life in Chicago.' They have yielded fresh

evidence that the differences between muscular fibers, such as those of the heart, which contract normally with what we call a spontaneous beat, and the fibers of the skeletal muscles, which only, under ordinary circumstances, contract when excited through their motor nerves, are not so deep-seated as was at one time supposed, since the addition of simple inorganic bodies to the living muscular substance, or their subtraction from it, can alter its behavior in this regard. The experiments of Langendorff, Porter and others on the action of the isolated hearts of warm-blooded animals, which, after being cut out of the body, can be kept alive for several hours by feeding them through their arteries with warm blood from a reservoir, have strengthened the belief that the essential cause of the heart-beat is to be sought in the muscular fibers and not in the nerve-cells present in certain portions of the organ.

With respect to the nerve-cell, research is at present largely concentrated upon the study of its minute structure. Among the numerous methods of staining employed for this purpose two deserve especial mention: the method of Golgi, which is peculiarly useful for bringing out the processes or branches of nerve-cells, and the method of Nissl, which is of great service in the investigation of the body of the cell. A typical nerve-cell when impregnated with a salt of silver, according to Golgi's method, exhibits a wonderful profusion of bifurcating processes, picked out in black like the sharply shadowed branches of a leafless tree under an electric light. But, however intricately the branches of neighboring cells may mingle and intertwine, they do not in general run into, or fuse with, each other, any more than the interlocking boughs of neighboring trees in a forest. By demonstrating this important fact the method of Golgi has revolutionized our ideas of the architecture of the nervous system.

The significance of the peculiar angular or spindle-shaped bodies in the protoplasm of the nerve-cell, which have been revealed by Nissl's method of staining with methylene-blue, is at present arousing the greatest interest. That they have some important relation to the nutrition of the cell seems evident. For when the latter is severed from that one of its processes (the axone) which constitutes the essential part of the nerve-fiber that springs from the cell, the Nissl bodies break up, and either disappear or are dispersed in the form of very minute granules of stainable material in the protoplasm. At the same time the cell becomes swollen, its nucleus is displaced to one side, and it may even atrophy entirely and disappear. As a rule, however, after several months it recovers its normal structure. The administration of considerable quantities of alcohol and other drugs causes a similar effect on the Nissl bodies. It has been known for half a century that the axone degenerates when cut off from the cell of which it is a process.

The fact that the cell suffers also is a striking illustration of the essential unity of the nerve-cell and all its branches, whether they are long or short—three feet in length, as the axones that run from the lower part of the spinal cord to the foot may be, or a thousandth of an inch, like some which arise and terminate within the gray matter of the cord and brain.

Simpler, at first sight, in their action and organization than nerve-cells or muscular fibers are the gland-cells which secrete the digestive juices. The cells of the kidney which separate from the blood the constituents of the urine, and the cells which line the intestine and are engaged in the absorption of the food appear to be simpler still. And simplest of all are the flat, scale-like cells that line the lungs and have to do with the taking in of oxygen and the elimination of carbonic acid and the similar cells which form the walls of the capillaries and are concerned in the production of lymph. Accordingly we have seen of late years, in connection with researches on the functions of such cells, a revival of formal discussion of the general problem of physiology: whether the vital processes can be completely explained in terms of the laws of unorganized matter. This is a question which has had a singular fate. Answered at certain epochs by an almost unanimous negative, it has emerged again with exery fresh advance in mechanical, physical or chemical knowledge, and for a time has seemed about to be settled in the affirmative. It was so in the seventeenth century when the discoveries of the new geometry and the new mechanics were hailed by Descartes and the iatro-mathematical school who were his lineal descendants, although they denied their parentage, as the key which was to unlock all the secrets of that cunningly devised automaton, the animal body, and particularly to explain its movements. At a later date, the determination of the laws of the diffusion of gases appeared to solve the problem of the passage of gases through the lungs, and the determination of the laws of diffusion of dissolved substances and of endosmosis, the problem of absorption from the intestines. With Ludwig's researches on the formation of urine, secretion seemed about to pass out of the group of mysterious 'vital' phenomena, and to become a mere process of filtration. But always as renewed investigation has brought into clearer light the peculiarities, the wizard tricks, one might almost say, of those rare mechanisms that ply so deftly even in the common business of the bodily machine, the gulf that separates the inorganic from the organized world has opened wide as ever, and physiology has still had to wait for a new Curtius to close it.

Quite recently the experiments of de Vries, Van't Hoff and others on osmosis have supplied further physical data for the solution of this perennial problem, and have, therefore, become the starting point of numerous physiological researches. Among these may be mentioned

a series of studies on absorption from the intestine by Waymouth Reid, which have just been published, in collected form, in the 'Philosophical Transactions of the Royal Society.' Starting with the idea of studying the behavior of the intestinal wall when as many as possible of the physical factors which may be supposed to be concerned in absorption have been eliminated, he endeavored to realize this condition by introducing into the intestine of an animal some of its own blood-serum. When this is done the cells that line the alimentary tube are in contact on one side with blood-serum and on the other with capillary vessels containing blood, the liquid portion of which has the same composition as the serum in the intestine. Under these circumstances there could be no passage of material from the intestines to the blood by diffusion or osmosis, if the intestinal wall acted like an ordinary dead membrane. Reid found, as a matter of fact, that the serum was rapidly absorbed. That this was not due to ordinary filtration, that is, to the squeezing of the liquid through the walls of the tube, follows from the fact that in these observations the pressure in the intestines was less than in the capillaries. He comes to the conclusion that while known physical forces play a certain part in absorption, there remains an unexplained residuum. But he refuses to speculate as to the cause of the peculiar endowments of the intestinal epithelium, and is very careful to point out that what seems so inexplicable now may later on become susceptible of explanation.

Friedenthal, in a suggestive paper occupied mainly by a critique of previous work and contemporary speculation, has lately taken up his parable in favor of a complete physico-chemical explanation of absorption. According to him, what we call the selective power of the intestinal epithelium is simply the expression of the fact that there exist in those cells substances which have a greater 'affinity' for certain constituents of the intestinal contents than for others, just as plates of gelatine do not take up the same quantities of different salts and other compounds from solutions containing them. Such hypotheses, of course, while they have the merit of directing attention to the possibility of a complete chemical or physical solution of the problem being some day found, do not give us any information as to the peculiarities of physical structure or chemical composition which confer on the lining of the intestine, as on all living cells, powers so remarkable that when we endeavor to describe them the terms which spring spontaneously to our lips are such as we should apply to the behavior of an entire organism in relation to its environment: 'selection,' 'discrimination,' 'affinity' for substances that are useful, 'antagonism' to those which are injurious.

The study of the permeability to various substances of what we may perhaps consider as the most simply organized cells in the whole body, the colored corpuscles of the blood, promises to throw a flood of light

on absorption in general. It has been lately shown that they are practically non-conductors of electricity in comparison with the liquid portion of the blood, or plasma, in which they float. This is due to the fact that the salts of the plasma, whose ions carry the electricity, penetrate the corpuscles with difficulty, sodium chloride, for example, scarcely passing into them at all. On the other hand, they are freely permeable to ammonium chloride, urea and other bodies. The conditions governing the passage of substances into the corpuscles are evidently very different from those which determine the permeability of an ordinary membrane. This is further shown by the fact that by certain methods of treatment the colossal molecules of the red coloring matter of the blood may be caused to escape from the corpuscles, while the much smaller molecules of the inorganic salts remain still pent within them. Such results are of great interest, for they show that cells which, as regards their main physiological office, the conveyance of oxygen to the tissues, seem to be governed strictly by the physical laws of diffusion of gases, appear to exercise a kind of 'selection' in the taking up of many substances which have nothing to do with their particular function. The suggestion is scarcely to be avoided that in this case a purely chemical or physical 'attraction' underlies the apparently selective power. And this idea is strengthened by the fact that all those characteristic reactions of the colored corpuscles can be obtained many hours after the blood has been removed from the body, and, therefore, at a time when their 'vital' activity may be supposed either to have been extinguished or to have undergone a serious diminution.

The absorption of oxygen and excretion of carbonic acid by the lungs have long been considered conspicuous examples of the passage of substances through a living animal membrane by ordinary physical diffusion. But, according to the recent observations of Bohr, oxygen may, within certain limits, be absorbed, when its partial pressure or tension in the blood is greater than that in the air contained in the lungs, and carbonic acid may be excreted when its pressure in the blood is less than that in the air of the lungs. Haldane and Smith have indeed shown that in man the pressure of the oxygen in the arterial blood is actually higher than in the outside air. These results are, of course, incompatible with a simple theory of diffusion, and show that the cells of the pulmonary membrane have the power of forcing oxygen to move in one direction and carbonic acid in the other even against the slope of pressure.

As regards the physiology of particular organs, attention has been, in recent years, attracted in a marked degree to two subjects: the so-called internal secretions of certain glands and the arrangement and actions of the nerve-cells and fibers which make up the central nervous system.

By an internal secretion we mean a substance or substances

formed by a gland and taken up from it by the blood or lymph. An ordinary external secretion is discharged by a special duct into the proper receptacle, bile, for example, into the gall-bladder, and ultimately into the intestine; urine into the urinary bladder, and so on. Some of the glands which produce important internal secretions have no ducts. Such are the thyroid glands, two insignificant looking reddish bodies situated in the neck, one at each side of the windpipe, a little below the larynx. It had been long known that disease of these glands, commencing in childhood and leading to the enlargement which we call goitre, was often associated with a condition of idiocy (cretinism). Interest in their functions was greatly stimulated by the discovery that excision of the thyroids was followed by grave changes resembling those found in a disease called myxœdema, and that the symptoms produced by excision, as well as those present in the natural disease, could be removed, and health restored, by feeding the patient with the raw or slightly cooked thyroids of animals or with certain extracts prepared from them. Much work has been devoted to the isolation in a pure form of the active substances, one of which contains iodine as an important constituent. It appears to be the office of the thyroid to manufacture for the use of the body a constant supply of these substances, which are necessary for the due maintenance of certain of its functions. In the absence of the natural supply, similar materials produced by the corresponding glands in animals can be utilized.

The suprarenal or adrenal bodies, situated just above the kidneys, are another pair of ductless glands whose function is of extraordinary importance in proportion to their size. It has been shown that they contain a substance which when injected into the blood in animals, or painted, say, on an inflamed eye in man, causes a marked narrowing of the small arteries; and it has been surmised that this substance, oozing slowly from the glands into the blood, exerts a bracing or 'tonic' influence on the muscular fibers of the heart and blood vessels, and helps to keep them in proper condition for their work. Certain it is that death follows their removal in animals, while their disorganization in man is associated with the peculiar and fatal condition termed Addison's disease.

The pituitary gland, a small body attached to the base of the brain, is in the same category. It seems to be of great importance, if not absolutely indispensable to life. Extracts of the gland, as Howell and Schäfer have shown, produce decided effects upon the pressure of the blood when injected into the vessels.

One of the most interesting examples of an internal secretion which is not necessary to life but which yet profoundly affects the chemical changes occurring in the body, is that of the ovaries. It has long been familiar to stock farmers that the removal of these organs greatly

increases the rapidity with which fat is laid on. According to the recent researches of Loewy and Richter at the Agricultural College in Berlin, the explanation is that the ovaries produce a substance which hastens the oxidation of the tissues and the food. When this substance is injected below the skin of animals whose ovaries have been removed, the tissue waste is markedly increased.

In the domain of nervous physiology our knowledge is growing apace. The doctrine of the localization of function on the surface of the brain may now be considered as well established. The motor region has been subdivided into areas, each of which is related to a particular movement, because the nerve-fibers springing from the large pyramidal cells contained in it, are connected with nerve-cells in the gray matter of the spinal cord which send nerve-fibers only to the muscles concerned in that movement. But while each motor center is thus connected by motor or efferent fibers with the muscles, recent work by Sherrington and Mott and by other observers has shown that it is also connected by sensory or afferent fibers with the muscles, the skin overlying them, the joints in their neighborhood, and the bones which they move. The 'motor area,' in fact, is not purely motor, but has sensory functions as well.

No convincing proof has yet been given that any particular portion of the brain is exclusively concerned in intellectual operations. Goltz, the most prominent representative of the dwindling band who still refuse to believe in the localization even of the motor functions, has lately published an interesting paper containing the results of observations on a monkey which was carefully watched for eleven years after the removal of the greater part of the gray matter of the middle and anterior portions of the left hemisphere of the brain. The character of the animal, whose little tricks and peculiarities had been studied for months before the operation, was entirely unaffected. All its traits remained unaltered. On the other hand, disturbances of movement on the right side were very noticeable up to the time of its death. It learned again to use the right limbs, but there was always a certain clumsiness in their movements. In actions requiring only one hand, the right was never willingly employed, and it evidently cost the animal a great effort to use it. Before the operation it would give either the right or the left hand when asked for it. After the operation it always gave the left, till by a long course of training, in which fruit or lumps of sugar served as the rewards of virtue, it learned again to give the right. Evidently, although this is not the interpretation placed by Goltz upon his observations, the motor centers of the right side of the brain, which normally preside over the movements of the left side of the body, had to be laboriously educated before they became able to carry out such movements of the right hand.

THE BLOOD OF THE NATION.

A STUDY OF THE DECAY OF RACES THROUGH THE SURVIVAL OF THE UNFIT.

PART I—IN PEACE.

BY DAVID STARR JORDAN,
PRESIDENT OF LELAND STANFORD JR. UNIVERSITY.

"Over trench and clod
Where we left the bravest of us,
There's a deeper green of the sod."
—Brownell.

I. In this paper I shall set forth two propositions, the one self-evident, the other not apparent at first sight, but equally demonstrable. *The blood of a nation determines its history.* This is the first proposition. The second is: *The history of a nation determines its blood.* As for the first, no one doubts that the character of men controls their deeds. In the long run and with masses of mankind this must be true, however great the emphasis we may lay on individual initiative or on individual variation.

Equally true is it that the present character of a nation is made by its past history. Those who are alive to-day are the resultants of the stream of heredity as modified by the vicissitudes through which the nation has passed. The blood of the nation flows in the veins of those who survive. Those who die without descendants can not color the stream of heredity. It must take its traits from the actual parentage.

II. The word 'blood' in this sense is figurative only, an expression formed to cover the qualities of heredity. Such traits, as the phrase goes, 'run in the blood.' In the earlier philosophy, it was held that blood was the actual physical vehicle of heredity, that the traits bequeathed from sire to son as the characteristics of families or races ran literally in the literal blood. We know now that this is not the case. We know that the actual 'blood' in the actual veins plays no part in heredity, that the transfusion of blood means no more than the transposition of food, and that the physical basis of the phenomena of inheritance is found in the structure of the germ cell and its contained germplasm.

III. But the old word well serves our purposes. The blood which is 'thicker than water' is the symbol of race unity. In this sense the

blood of the people concerned is, at once, the cause and the result of the deeds recorded in their history. For example, wherever an Englishman goes, he carries with him the elements of English history. It is a British deed which he does, British history that he makes. Thus, too, a Jew is a Jew in all ages and climes, and his deeds everywhere bear the stamp of Jewish individuality. A Greek is a Greek; a Chinaman remains a Chinaman. In like fashion, the race traits color all history made by Tartars, or negroes, or Malays.

The climate which surrounds a tribe of men may affect the activities of these men as individuals or as an aggregate; education may intensify their powers or mellow their prejudices; oppression may make them servile or dominion make them overbearing, but these traits and their resultants, so far as science knows, do not 'run in the blood.' They are not 'bred in the bone.' Older than climate or training or experience are the traits of heredity, and in the long run it is always 'blood which tells.'

IV. On the other hand, the deeds of a race of men must in turn determine its blood. Could we with full knowledge sum up the events of the past history of any body of men, we could indicate the kinds of men destroyed in these events. The others would be left to write the history of the future. It is the 'man who is left' in the march of history who gives to history its future trend. By the 'man who is left' we mean simply the man who remains at home to become the father of the family—as distinguished from the man who in one way or another is sacrificed for the nation's weal or woe. If any class of men be destroyed by political or social forces, or by the action of institutions, they leave no offspring, and their like will cease to appear.

V. 'Send forth the best ye breed.' This is Kipling's cynical advice to a nation which happily can never follow it. But could it be accepted literally and completely, the nation in time would breed only second-rate men. By the sacrifice of their best, or the emigration of the best, and by such influences alone, have races fallen from first-rate to second-rate in the march of history.

VI. For a race of men or a herd of cattle are governed by the same laws of selection. Those who survive inherit the traits of their own actual ancestry. In the herd of cattle, to destroy the strongest bulls, the fairest cows, the most promising calves, is to allow those not strong, nor fair, nor promising, to become the parents of the coming herd. Under this influence the herd will deteriorate, although the individuals of the inferior herd are no worse than their own actual parents. Such a process is called race-degeneration, and it is the only race-degeneration known in the history of cattle or men. The scrawny, lean, infertile herd is the natural offspring of the same type of parents. On the other hand, if we sell or destroy the rough, lean, or feeble calves we shall have

a herd descended from the best. It is said that when the short-horned Durham cattle first attracted attention in England, the long-horns, which preceded them, inferior for beef or milk, vanished 'as if smitten by a pestilence.' The fact was that, being less valuable, their owners chose to destroy them rather than the finer Durhams. Thus the new stock came from the better Durham parentage. If conditions should ever be reversed, and the Durhams were chosen for destruction, then the long-horns might again appear, swelling in numbers as if by magic, unless all traces of the breed had in the meantime been annihilated.

VII. In selective breeding with any domesticated animal or plant, it is possible, with a little attention, to produce wonderful changes for the better. Almost anything may be accomplished with time and patience. To select for posterity those individuals which best meet our needs or please our fancy, and to destroy those with unfavorable qualities, is the function of artificial selection. Add to this the occasional crossing of unlike forms to promote new and desirable variations, and we have the whole secret of selective breeding. This process Youatt calls the 'magician's wand' by which man may summon up and bring into existence any form of animal or plant useful to him or pleasing to his fancy.

VIII. In the animal world progress comes mainly through selection, natural or artificial, the survival of the fittest to become the parent of the new generation. In the world of man similar causes produce similar results. The word progress is, however, used with a double meaning, including the advance of civilization, as well as race improvement. The first of these meanings is entirely distinct from the other. The results of training and education lie outside the scope of the present discussion. By training the force of the individual man is increased. Education gives him access to the accumulated stores of wisdom built up from the experience of ages. The trained man is placed in a class relatively higher than the one to which he would belong on the score of heredity alone. Heredity carries with it possibilities for effectiveness. Training makes these possibilities actual. Civilization has been defined as 'the sum total of those agencies and conditions by which a race may advance independently of heredity.' But while education and civilization may greatly change the life of individuals, and through them that of the nation, these influences are spent on the individual and the social system of which he is a part. So far as science knows, education and training play no part in heredity. The change in the blood which is the essence of race-progress, as distinguished from progress in civilization, finds its cause in selection only.

IX. To apply to nations the principles known to be valid in cattle-breeding, we may take a concrete example—that of the alleged decadence of France. It is claimed that the birth-rate is falling off in

France, that the stature is lower, and the physical force less among the French peasantry than it was a century ago. If all this is true, then the cause for it must be in some feature of the life of France which has changed the normal processes of selection.

X. In the present paper I shall not attempt to prove these statements. They rest, so far as I know, entirely on assertions of French writers, and statistics are not easily obtained. It suffices that an official commission has investigated the causes of reduced fertility, with chiefly negative results. It is not due primarily to intemperance nor vice nor prudence nor misdirected education, the rush to 'ready-made careers,' but to inherited deficiencies of the people themselves. It is not a matter of the cities alone, but of the whole body of French peasantry. Legoyt, in his study of 'the alleged degeneration of the French people,' tells us that "it will take long periods of peace and plenty before France can recover the tall statures mowed down in the wars of the republic and the First Empire," though how plenty can provide for the survival of the tallest this writer does not explain. Peace and plenty may preserve, but they can not restore.

It is claimed, on authority which I have failed to verify, that the French soldier of to-day is nearly two inches shorter than the soldier of a century ago. One of the most important of recent French books, by Edmond Demolins, asks, "in what consists the superiority of the Anglo-Saxon?" The answer is found in defects of training and of civic and personal ideals, but the real cause lies deeper than all this. Low ideals in education are developed by inferior men. Dr. Nordau and his school of exponents of 'hand-painted science' find France a nation of decadents, a condition due to the inherited strain of an overwrought civilization. With them the word 'degenerate' is found adequate to explain all eccentricities of French literature, art, politics, or jurisprudence.

XI. But science knows no such things as nerve-stress inheritance. If it did, the peasantry of France have not been subjected to it. Their life is hard, no doubt, but not stressful, and they suffer more from nerve-sluggishness than from any form of enforced psychical activity. The kind of degeneration Nordau pictures is not a matter of heredity. When not simply personal eccentricity, it is a phase of personal decay. It finds its causes in bad habits, bad training, bad morals, or in the desire to catch public attention for personal advantage. It has no permanence in the blood of the race. The presence on the Paris boulevards of a mob of crazy painters, maudlin musicians, drunken poets, and sensation-mongers proves nothing as to race degeneracy. When the fashion changes they will change also. Already the fad of 'strenuous life' is blowing them away. Any man of any race withers in an atmosphere of vice, absinthe and opium. The presence of such an at-

mosphere may be an effect of race decadence, but it is not a cause of the lowered tone of the nation.

Evil influences may kill the individual, but they can not tarnish the stream of heredity. The child of each generation is free-born so far as heredity goes, and the sins of the fathers are not visited upon him. If vice strikes deeply enough to wreck the man, it is likely to wreck or kill the child as well, not through heredity, but through lack of nutrition. The child depends on its parents for its early vitality, its constitutional strength, the momentum of its life, if we may use the term. For this a sound parentage demands a sound body. The unsound parentage yields the withered branches, the lineage which speedily comes to the end. But this class of influences, affecting not the germplasm, but general vitality, has no relation to hereditary qualities, so far as we know.

In heredity there can be no tendency downward or upward. Nature repeats, and that is all. From the actual parents actual qualities are received, the traits of the man or woman as they might have been, without regard, so far as we know, to the way in which these qualities have been actually developed.

XII. The evolution of a race is selective only, never collective. Collective evolution, the movement upward or downward of a people as a whole, irrespective of education or of selection, is, as Lepouge has pointed out, a thing unknown. 'It exists in rhetoric, not in truth nor in history.'

No race as a whole can be made up of 'degenerate sons of noble sires.' Where decadence exists, the noble sires have perished, either through evil influences, as in the slums of great cities, or else through the movements of history or the growth of institutions. If a nation sends forth the best it breeds to destruction, the second best will take their vacant places. The weak, the vicious, the unthrifty will propagate, and in default of better, will have the land to themselves.

XIII. We may now see the true significance of the 'Man of the Hoe,' as painted by Millet and as pictured in Edwin Markham's verse. This is the Norman peasant, low-browed, heavy-jawed, 'the brother of the ox,' gazing with lack-lustre eye on the things about him. To a certain extent, he is typical of the French peasantry. Every one who has traveled in France knows well his kind. If it should be that his kind is increasing, it is because his betters are not. It is not that his back is bent by centuries of toil. He was not born oppressed. Heredity carries over not oppression, but those qualities of mind and heart which invite or which defy oppression. The tyrant harms those only that he can reach. The new generation is free-born and slips from his hands, unless its traits be of the kind which demand new tyrants.

Millet's Man of the Hoe is not the product of oppression. He is

primitive, aboriginal. His lineage has always been that of the clown and swineherd. The heavy jaw and slanting forehead can be found in the oldest mounds and tombs of France. The skulls of Engis and Neanderthal were typical men of the hoe, and through the days of the Gauls and Romans the race was not extinct. The 'lords and masters of the earth' can prove an alibi when accused of the fashioning of the terrible shape of this primitive man. And men of this shape persist to-day in regions never invaded by our social or political tyranny, and their kind is older than any existing social order.

That he is 'chained to the wheel of labor' is the result, not the cause, of his impotence. In dealing with him, therefore, we are far from the 'labor problem' of to-day, far from the workman brutalized by machinery, and from all the wrongs of the poor set forth in the conventional literature of sympathy.

XIV. In our discussion of decadence we turn to France first simply as a convenient illustration. Her sins have not been greater than those of other lands, nor is the penalty more significant. Her case rises to our hand to illustrate a principle which applies to all human history and to all history of groups of animals and plants as well. Our picture, such as it is, we must paint with a broad brush, for we have no space for exceptions and qualifications, which, at the most, could only prove the rule. To weigh statistics is impossible, for the statistics we need have never been collected. The evil effects of 'military selection' and allied causes have been long recognized by students of social science; but their ideas have not penetrated into the common literature of common life.

The survival of the fittest in the struggle for existence is the primal cause of race progress and race changes. But in the red field of human history the natural process of selection is often reversed. The survival of the unfittest is the primal cause of the downfall of nations. Let us see in what ways this cause has operated in the history of France.

XV. First, we may consider the relation of the nobility to the peasantry, the second to the third estate.

The feudal nobility of each nation was in the beginning made up of the fair, the brave and the strong. By their courage and strength their men became the rulers of the people, and by the same token they chose the beauty of the realm to be their own.

In the polity of England this superiority was emphasized by the law of primogeniture. On 'inequality before the law' British polity has always rested. Men have tried to take a certain few to feed these on 'royal jelly,' as the young queen bee is fed, and thus to raise them to a higher class—distinct from all the workers. To take this leisure class out of the struggle and competition of life, so goes the theory, is to make of the first-born and his kind harmonious and perfect men and

women, fit to lead and control the social and political life of the state. In England, the eldest son is chosen for this purpose, a good arrangement, according to Samuel Johnson, 'because it ensures only one fool in the family.' For the theory of the leisure class forgets that men are made virile by effort and resistance, and the lord developed by the use of 'royal jelly' has rarely been distinguished by perfection of manhood.

The gain of primogeniture came in the fact that the younger sons and the daughters' sons were forced constantly back into the mass of the people. Among the people at large this stronger blood became the dominant strain. The Englishmen of to-day are the sons of the old nobility, and in the stress of natural selection they have crowded out the children of the swineherd and the slave. The evil of primogeniture has furnished its own antidote. It has begotten democracy. The younger sons in Cromwell's ranks asked on their battle-flags why the eldest should receive all and they nothing. Richard Rumbold, whom they slew in the Bloody Assizes, "could never believe that Providence had sent into the world a few men already booted and spurred, with countless millions already saddled and bridled for these few to ride." Thus these younger sons became the Roundhead, the Puritan, the Pilgrim. They swelled Cromwell's Army, they knelt at Marston Moor, they manned the Mayflower, and in each generation they have fought for liberty in England and in the United States. Studies in genealogy show that all this is literally true. All the old families in New England and Virginia trace their lines back to nobility, and thence to royalty. Almost every Anglo-American has, if he knew it, noble and royal blood in his veins. The Massachusetts farmer, whose fathers came from Plymouth in Devon, has as much of the blood of the Plantagenets, of William and of Alfred as flows in any royal veins in Europe. But his ancestral line passes through the working and fighting younger son, not through him who was first born to the purple. The persistence of the strong shows itself in the prevalence of the leading qualities of her dominant strains of blood, and it is well for England that her gentle blood flows in all her ranks and in all her classes. When we consider with Demolins 'what constitutes the superiority of the Anglo-Saxon,' we shall find his descent from the old nobility, 'Saxon and Norman and Dane,' not the least of its factors.

XVI. On the continent of Europe the law of primogeniture existed in less force, and the results were very distinct. All of noble blood were continuously noble. All belonged to the leisure class. All were held on the backs of a third estate, men of weaker heredity, beaten lower into the dust by the weight of an ever-increasing body of nobility. The blood of the strong rarely mingled with that of the clown. The noblemen were brought up in indolence and ineffectiveness. The evils of dissipation wasted their individual lives, while casting an ever-in-

creasing burden on the villager and on the 'farmer who must pay for all.'

XVII. Hence in France the burden of taxation led to the Revolution and its Reign of Terror. I need not go over the details of dissipation, intrigue, extortion and vengeance which brought to sacrifice the 'best that the nation could bring.' In spite of their lust and cruelty, the victims of the Reign of Terror were literally the best from the standpoint of race development. Their weaknesses were those of training in luxury and irresponsible power. These effects were individual only, and their children were free-born, with the capacity to grow up truly noble if removed from the evil surroundings of the palace.

XVIII. In Thackeray's 'Chronicle of the Drum,' the old drummer, Pierre, tells us that

> "Those glorious days of September
> Saw many aristocrats fall,
> 'Twas then that our pikes drank the blood
> In the beautiful breast of Lamballe.
>
> "Pardi, 'twas a beautiful lady,
> I seldom have looked on her like,
> And I drummed for a gallant procession
> That marched with her head on a pike."

Then they showed her pale face to the Queen, who fell fainting, and the mob called for her head and the head of the King. And the slaughter went on until the man on horseback came, and the mob, 'alive but most reluctant,' was itself forced into the graves it had dug for others.

And since that day the 'best that the nation could bring' have been without descendants, the men less manly than the sons of the Girondins would have been, the women less beautiful than the daughters of Lamballe. The political changes which arose may have been for the better; the change in the blood was all for the worse.

XIX. Other influences which destroyed the best were social repression, religious intolerance and the intolerance of irreligion and unscience. It was the atheist mob of Paris which destroyed Lavoisier, with the sneer that the new republic of reason had no use for savants. The old conservatism burned the heretic at the stake, banished the Huguenot, destroyed the lover of freedom, silenced the agitator. Its intolerance gave Cuvier and Agassiz to Switzerland, sent the Le Contes to America, the Jouberts to Holland, and furnished the backbone of the fierce democracy of the Transvaal. While not all agitators are sane, and not all heretics right-minded, yet no nation can spare from its numbers those men who think for themselves and those who act for themselves. It cannot afford to drive away or destroy those who are filled with religious zeal, nor those whose religious zeal takes a form not approved by tradition nor by consent of the masses. All

movements toward social and religious reform are signs of individual initiative and individual force. The country which stamps out individuality will soon live in the mass alone.

XX. A French writer has claimed that the decay of religious spirit in France is connected with the growth of religious orders of which celibacy is a prominent feature. If religious men and women leave no descendants, their own spirit, at least, will fail of inheritance. A people careless of religion inherit this trait from equally careless ancestors.

XXI. Indiscriminate charity has been a fruitful cause of the survival of the unfit. To kill the strong and to feed the weak is to provide for a progeny of weakness. It is a French writer again, who says that "Charity creates the misery she tries to relieve; she can never relieve half the misery she creates."

There is to-day in Aosta, in Northern Italy, an asylum for the care and culture of idiots. The crétin and the goitre are assembled there, and the marriage of those who can not take care of themselves ensures the preservation of their strains of unfitness. By caring devotedly for those who in the stress of life could not live alone for a week and by caring for their children, generation after generation, the good people of Aosta have produced a new breed of men, who can not even feed themselves. These are incompetent through selection of degradation, while the 'man of the hoe' is primitively ineffective.

The growth of the goitre in the valleys of Savoy, Piedmont and Valais is itself in large part a matter of selection. The boy with the goitre is exempt from military service. He remains at home to become the father of the family. It is said that at one time the government of Savoy furnished the children of that region with lozenges of iodine, which were supposed to check the abnormal swelling or the thyroid gland, known as the goitre. This disease is a frequent cause of idiocy or cretinism, as well as its almost constant accompaniment. It is said the mothers gave the lozenges only to the girls, preferring that the boys should grow up to the goitre rather than to the army. The causes of goitre are obscure, perhaps depending on poor nutrition, or on mineral substances in the water. The disease itself is not hereditary so far as known, but susceptibility to it certainly is. By taking away for outside service those who are resistant, the heredity of tendency to goitrous swelling is fastened on those who remain.

Like these mothers in Savoy was a mother in Germany. Not long since, a friend of the writer, passing through a Franconian forest, found a young man lying senseless by the way. It was a young recruit for the army who had got into some trouble with his comrades. They had beaten him and left him lying with a broken head. Carried to his home, his mother fell on her knees and thanked God, for this injury had saved him from the army.

XXII. The effect of alcoholic drink on race progress should be considered in this collection. Authorities do not agree as to the final result of alcohol in race selection. Doubtless, in the long run, the drunkard will be eliminated, and perhaps certain authors are right in regarding this as a gain to the race. On the other hand, there is great force in Dr. Amos G. Warner's remark, that of all caustics gangrene is the most expensive. The people of southern Europe are relatively temperate. They have used wine for centuries, and it is thought by Archdall Reid and others that the cause of their temperance is to be found in this long use of alcoholic beverages. All those with vitiated or uncontrollable appetites have been destroyed in the long experience with wine, leaving only those with normal tastes and normal ability of resistance. The free use of wine is, therefore, in this view, a cause of final temperance, while intemperance rages only among those races which have not long known alcohol, and have not become by selection resistant to it. The savage races which have never known alcohol are even less resistant, and are soonest destroyed by it.

In all this there must be a certain element of truth. The view, however, ignores the evil effect on the nervous system of long-continued poisoning, even if the poison be only in moderate amounts. The temperate Italian, with his daily semi-saturation is no more a normal man than the Scotch farmer with his occasional sprees. The nerve disturbance which wine effects is an evil, whether carried to excess in regularity or irregularity. We know too little of its final result on the race to give certainty to our speculations. It is moreover true that most excess in the use of alcohol is not due to primitive appetite. It is drink which causes appetite, and not appetite which seeks for drink. In a given number of drunkards but a very few become such through inborn appetite. It is influence of bad example, lack of courage, false idea of manliness, or some defect in character or misfortune in environment which leads to the first steps in drunkenness. The taste once established takes care of itself. In earlier times, when the nature of alcohol was unknown and total abstinence was undreamed of, it was the strong, the boisterous, the energetic, the apostle of 'the strenuous life,' who carried all these things to excess. The wassail bowl, the bumper of ale, the flagon of wine, all these were the attribute of the strong. We can not say that those who sank in alcoholism thereby illustrated the survival of the fittest. Who can say that as the Latin races became temperate they did not also become docile and weak? In other words, considering the influence of alcohol alone, unchecked by an educated conscience, we must admit that it is the strong and vigorous, not the weak and perverted, that are destroyed by it. At the best, we can only say that alcoholic selection is a complex force, which makes for temperance—if at all, at a fearful cost of life which without alcoholic temp-

tation would be well worth saving. We cannot easily, with Mr. Reid, regard alcohol as an instrument of race-purification, nor believe that the growth of abstinence and prohibition only prepares the race for a future deeper plunge into dissipation. If France, through wine, has grown temperate, she has grown tame. "New Mirabeaus," Carlyle tells us, "one hears not of; the wild kindred has gone out with this, its greatest." This fact, whatever the cause, is typical of great, strong, turbulent men who led the wild life of Mirabeau because they knew nothing better.

XXIII. The concentration of the energies of France in the one great city of Paris is again a potent agency in the impoverishment of the blood of the rural districts. All great cities are destroyers of life. Scarcely one would hold its own in population or power were it not for the young men of the farms. In such destruction Paris has ever taken the lead. The education of the middle classes in France is almost exclusively a preparation for public life. To be an official in a great city is an almost universal ideal. This ideal but few attain, and the lives of the rest are largely wasted. Not only the would-be official, but artist, poet, musician, physician or journalist seeks his career in Paris. A few may find it. The others, discouraged by hopeless effort or vitiated by corrosion, faint and fall. Every night some few of these cast themselves into the Seine. Every morning they are brought to the morgue behind the old Church of Notre Dame. It is a long procession and a sad one from the provincial village to the strife and pitfalls of the great city, from hope and joy to absinthe and the morgue. With all its pitiful aspects the one which concerns us is the steady drain on the life-blood of the nation: its steady lowering of the average of the parent stock of the future.

XXIV. But far more potent for evil to the race than all these influences, large and small, is the one great destroyer—War. War for glory, war for gain, war for dominion, its effect is the same whatever its alleged purpose.

SCIENTIFIC LITERATURE.

ETHICS AS A SCIENCE.

THANKS to such writers as Spencer, Stephen and Sutherland, we have been long familiar with ethics treated from a scientific standpoint. Yet the science of ethics, as pursued by these thinkers, betrayed one evident defect—it proceeded by analogy from the physical sciences. In the new work, entitled 'Ethics, Descriptive and Explanatory' (Macmillan), by Professor Mezes, of the University of Texas, an effort is made to remove this reproach. His aim "is to give as adequate critical and methodical an account as possible of what morality and immorality *are* . . . to construct a positive or purely scientific theory of Ethics, and to give a naturalistic account of all the aspects of morality and immorality." Mr. Mezes does not forget that this is a vast undertaking, one not to be compassed within the limits of a text-book such as this professes to be. But, remembering these restrictions, we may say that he has produced an excellent work; indeed, so excellent, that it were well worth his while to consider whether it might not be wise for him to view it as the prospectus of a far more ambitious undertaking, in which some, if not all, the major problems could be wrought out with fullness. The plan pursued by Mr. Mezes is as follows: In the Introduction, he defines ethics, shows its scope and method, and distinguishes between moral and non-moral phenomena. The body of the book consists of two parts, the first dealing with subjective morality and the individual conscience; the second discussing objective morality, and embracing, among other inquiries, an admirable analysis of justice. A conclusion treats the nature and value of morality. As the work is undoubtedly of considerable importance, several interesting features deserve mention. Mr. Mezes is thoroughly objective in his method, and so approaches, within his chosen sphere, the standpoint which a biologist might occupy in his. Significant in this connection is his shrewd suggestion that ethics is not to be treated as a teleological science till you come to the end of it. He is to be commended greatly, further, for the even-handed way in which he grapples with the ticklish questions of conscience and the like. He shows clearly that *Moralitat*, while by no means of the importance assigned it by the traditional English and theological moralists, cannot be overlooked. In particular, he contrives to put the results of psychological research to good use in his analysis. This is one of several pleasing and hopeful features. Similarly, in this connection, he rids himself of the time-honored static conception of conscience, and, by adopting a dynamic theory, actually vindicates a concrete place in moral life for this hoary abstraction. So, too, when he passes to objective morality *(Sittlichkeit)*, and makes contact with the cardinal virtues. Under his sober hand, these cease to be vague entities floating in mid-air, and come to take their places as vital results of objective morality—results shot out, as it were, by the interaction of man with man. The chapter on justice deserves to rank with the best discussions of the subject. Mr. Mezes, in short, has managed to free himself from many of the stultifications that have beset scientific moralists in the past. Whether he has emancipated himself from all need not be discussed now. It is sufficient to note that he has produced a fresh, suggestive and most careful work; that he has adopted and held fast to a scientific

standpoint in ethics—not in biology or psychology or any other science, and that, therefore, he has advanced the cause of objective research in this most baffling field. A few books of this character and the present inextricable tangle in ethical theory might be in a fair way toward ravelling up.

BOTANICAL BOOKS.

DR. D. H. SCOTT has rewritten a series of lectures given at the University College, London, 1896, and published them under the title of 'Studies in Fossil Botany' (A. & C. Black). This book will be a most useful one to the botanist, since it presupposes no knowledge of paleontology, and discusses only the portions of a subject of major importance to the student of plants. A perusal of this work will impress the reader with the enormous amount of light thrown on the natural affinities of plants by the results of paleobotanical investigations during the last ten or twelve years.

'ELEMENTS DE PALEOBOTANIQUE' (Carré & Naud), by R. Zeiller, is a comprehensive text-book, in which the entire subject receives a thorough and systematic treatment. The preservation of fossils, classification and nomenclature, systematic examination of the principal types of fossil vegetation, floral succession, climate, etc., are among the principal topics taken up at length. The bibliographic list in the appendix covers eighteen pages and is inclusive of the greater number of important titles.

PROFESSOR PERCIVAL, of Southeastern Agricultural College, Kent, England, has written a text-book of 'Agricultural Botany' (Duckworth & Co.), which will meet the needs of students interested in plants from a cultural point of view more nearly than any similar text-book hitherto published. The eight chief divisions of the book are concerned with the general external morphology of the plant, internal morphology, physiology, classification, and special botany of farm crops, weeds, farm seeds and fungi, considered chiefly in relation to some of the common diseases of plants and bacteria. The matter is arranged in two portions; a didactic discussion of the principles of the subject, which has been kept as free as might be from technicalities, and a series of demonstrations and experiments, by which all the more important points are actually seen in the plant. The point of view throughout the entire book is entirely different from that of the lecturer on pure botany, and the perspective of the entire subject is rearranged to meet the new conditions. It is impossible, of course, that all the more important recent discoveries, even in such a basal portion of the work as the nutrition of plants, should be put into practise immediately, but it is to be said that Professor Percival's book is fairly abreast of the times, although adhering to some anachronisms. The introduction and use of the book in America would be followed by a notable improvement of the instruction in botany in most agricultural schools.

'THE NEW FORESTRY' (Pawson & Brailsford, Sheffield), by Mr. John Simpson, is a manual adapted to British woodlands and game preservation. One chapter is devoted to the management of a woodland as a place for sheltering and rearing pheasants and other game birds and animals. The remaining chapters are devoted to practical directions as to rotation, allotment, cultural methods and general administration of forests, with a consideration of the numerous factors that must be taken into account in forestry operations on an English estate. The practical value of the book is enhanced by estimates of expenses and selling values.

THE BEET SUGAR INDUSTRY.

THE report on the 'Progress of the Beet-Sugar Industry in the United States in 1899' presents a very hopeful outlook for the success of this industry over a quite wide range of territory. The report was prepared by the Department

of Agriculture on the basis of extensive observations in the field and at beet-sugar factories, and chemical examination of beets grown at a large number of places in forty-one States and Territories. Experiments to determine the regions best adapted to profitable beet culture have been in progress for several years past, and in connection with similar work conducted by the State experiment stations, have in large measure settled this question. On the basis of the results, over 30 beet-sugar factories have been established and are in successful operation. A number of others are now building, and still others are in contemplation, if contracts can be made with farmers for growing the beets. California has eight factories, including the largest factory in the world, with a capacity for working 3,000 tons of sugar beets per day, which is an indication of the energy with which this new industry is starting in America. It was expected that 35,000 acres of beets would be grown for this factory in 1900. Nine factories were in operation in Michigan, where for several reasons the conditions are considered particularly favorable to the industry, and the greatest interest has been manifested in its development. An interesting feature of the factory at Lehi, Utah, is the establishment of a slicing station or subfactory at a point thirty miles away, where the juice is extracted from the beets, limed and piped to the main factory. Another subfactory in an opposite direction is planned, increasing the capacity of the combined plant to 1,200 tons of beets a day. This plan of having 'slicing stations' connected with the main factory by pipe lines is a novel one, and is believed to be a distinct advancement. It saves expense in hauling the beets and brings a larger radius of farming country into close contact with the sugar factory. The factory at Carlsbad, New Mexico, is said to be the only factory in the world where sugar beets are grown entirely with irrigation. Its demonstration of the feasibility of this is considered a valuable lesson for the arid regions. The average cost of raising an acre of sugar beets, under conditions similar to those in Iowa, for example, is given as $30, and the yield at from twelve to fifteen tons, although under extraordinary conditions it may reach twenty-five tons. The price paid for beets by the factories depends in many cases on the sugar content, but averages about $4 to $4.50 per ton. In many localities where the conditions are favorable it has been demonstrated to the satisfaction of the farmer that a larger profit can be realized from growing sugar beets than any other crop, and in addition the land is improved by the superior cultivation given this crop. Furthermore, the value of the extracted sugar-beet pulp as a feeding stuff for animals is urged as an additional advantage to the agriculture in the vicinity of beet-sugar factories, which is being appreciated. This pulp is usually given away for the hauling, but in some cases the factories themselves have erected feeding pens, where large numbers of cattle and sheep have been fattened. Time and effort have been required to induce farmers to take up the growing of beets on account of the large amount of labor and the expense involved, and many expensive lessons have had to be learned in the operation of factories; but the industry is now believed to be well on its feet, with a good prospect of steady growth.

THE PROGRESS OF SCIENCE.

THERE appears to be no abatement in expeditions for polar discovery and adventure. Lieutenant Peary remains in the far north, seeking to reach a point nearer to the Pole than did Dr. Nansen and the Duke of Abruzzi's party, while with the same object in view Mr. Baldwin is preparing an expedition, liberally equipped by Mr. Ziegler, of New York City, and Captain Bernier is making efforts to secure a similar outfit in Canada. These expeditions are perhaps not primarily for scientific research, though they should add to knowledge in many directions. The expeditions being fitted out with the assistance of the German and British Governments for antarctic exploration are, however, strictly scientific in character. Exploration in the north has never relaxed, but since Sir James Ross returned, in 1843, efforts to explore the south polar region have been sporadic and comparatively unimportant, until the recent expeditions under Captain de Gerlache and Mr. Borchgrevink. The scientific results of these expeditions have not yet been published, though descriptive volumes by Mr. Borchgrevink and Dr. Cook have recently been issued, and the latter has contributed to the present number of this Journal an interesting account of the unknown southern aurora. The 'Belgica,' from which Dr. Cook made his observations, was not, however, altogether fortunate in its course, and possibly the dramatic interest of the first antarctic night is greater than the scientific interest of the results. Mr. Borchgrevink followed pretty closely in the track of Sir James Ross, and his own book contributes little or nothing to scientific knowledge. He reached by a day's expedition a point furthest to the south, but it is not even obvious how he determined this, when he estimates the semi-diameter of the sun as 16° 17′ 1″. However valuable the scientific results of the voyages of the 'Belgica' and of the 'Southern Cross' may prove when published, there is certainly room for the great expeditions now being made ready in England and in Germany.

THE 'Discovery,' which will carry the British Antarctic Expedition, was launched on March 21 from the yard of the Dundee Shipbuilders' Company. No fewer than six ships with this name have been engaged in British exploration, and the present vessel is somewhat similar to its namesake, which took part in Sir George Nares's expedition in 1875. But it, of course, contains all modern improvements, and is of unusual strength. The oak ribs are placed as close together as possible. These are covered on the outside with oak and greenheart and on the inside with asbestos, while the bow is cased with steel plates. The tonnage is 1,750, the length at the water line 172 feet, and the extreme breadth 33 feet. The engines are of 450 horse power, giving a speed of about eight knots an hour, but to save coal they will be sparingly used, the vessel being rigged as a bark with three masts. Great care has been taken with the interior fittings to secure the greatest possible efficiency of scientific work, with due regard to the comfort of the company. The vessel is under the command of Capt. Robert Scott, and Prof. J. W. Gregory, who has recently gone from the British Museum to Melbourne University, is in charge of the scientific work. The expedition will begin its work at Victoria Land, facing New Zealand, where Ross and, recently, Mr. Borchgrevink, have

explored furthest to the south. The German expedition, under Dr. von Drygalski, is also making active preparation, and its vessel—which has been named 'Gauss,' in honor of the great mathematician—was launched on April 1. Expeditions to cooperate with those from England and Germany are also planned in Scotland and Sweden. It seems unfortunate that the United States, which sixty years ago, at the time of the great antarctic expeditions by Ross, d'Urville and Balleny, sent Wilkes with five vessels, should not be represented in the present movement to make a thorough exploration of the antarctic regions.

WHILE Great Britain is sending out its antarctic expedition at a cost of $500,000, a less pretentious, but perhaps equally interesting expedition is being planned. In view of the enormous importance attached to the recent discoveries of the relation of mosquitoes to malaria, and perhaps to yellow fever, Dr. Patrick Manson has urged the sending of a party to the islands of the Pacific, and, in the first instance, to Samoa, to study the life history of the mosquito and the conditions on which its existence and development depend. In certain of the islands of the Pacific, elephantiasis, a disease also due to the mosquito, is so prevalent that it occurs in half or more of the population, while in other islands it is entirely absent. It is hoped that the study of the distribution of mosquitoes, and, perhaps, experiments on their introduction, may show what is antagonistic to their development, thus making it possible to find a means of destroying them when they are present. Towards this plan the sum of $2,500 has been subscribed anonymously, and it is hoped that the British Government will assist in providing the $10,000 necessary to carry it into effect. It seems evident that the Department of Agriculture should at once undertake the study of the distribution of the malaria-bearing mosquitoes in the United States. The annual money loss to the country through the prevalence of malaria may be as little as $10,000,000 or as much as $100,000,000, but it is in any case so enormous that a thorough investigation, at whatever cost, would be in the direction of the strictest economy. There are, for example, no *Anopheles* on Manhattan Island, but within a mile of it they are abundant and malaria is prevalent. It may be supposed that the value of real estate, at the seashore and mountain resorts, for example, will be doubled or halved, according as *Anopheles* are absent or present.

THE plague has now been so long prevalent in India that the newspapers no longer regard it as necessary to report on it, and probably very few think of its ravages, yet the deaths in Bengal alone during the last week, of which reports are at hand, were 4,000, and the recent census of India shows that the population of Bombay is 50,000 less than before the epidemic. The occurrence of the plague at Cape Town has, however, attracted notice, in view of the possibility of its spreading in the British Army, and attention has recently been called to the existence of the disease in San Francisco. It has for a long time been known in medical circles that there have been cases of plague in the Chinese quarters, but the State authorities have denied their existence and have attempted to suppress any information in regard to the epidemic. It appears that Secretary Gage appointed some time since, in spite of the protest of the Governor of California, a commission to investigate the matter. This commission, consisting of Prof. Simon Flexner, of the University of Pennsylvania; Prof. F. G. Novy, of the University of Michigan, and Prof. L. F. Barker, of the University of Chicago, has made a thorough investigation and has presented a report, from which it appears that thirty-two fatal cases have occurred in San Francisco during the past year; and this probably is incomplete, as six deaths were

discovered by the commission referred to above in the course of a single week, and no cases have been reported that were not fatal. The State has now been aroused, and has appropriated $100,000 for the Board of Health to use in the suppression of the epidemic. One branch of the Legislature passed a most extraordinary bill, making it a felony to publish, by writing or printing, that Asiatic cholera or bubonic plague exists within the State, unless the fact has been determined by the State Board of Health and entered upon its minutes, but this measure appears now to have been dropped. The San Francisco papers have apparently been only too ready to suppress information in regard to the plague in that city. It appears that the epidemic is slight, but it will naturally be exaggerated by attempts to deny its existence for commercial reasons.

WITHIN the past six months the attention of the English public has been attracted in an unwonted degree to the question of the purity of alcoholic liquors. There occurred last fall, in Lancashire, and especially in Manchester and its vicinity, large numbers of cases of arsenical poisoning, which were finally traced to the consumption of a particular brand of beer. Further investigation revealed the fact that the manufacturers of this beer used, in brewing, glucose of a certain make, and that the manufacturers of this glucose had recently begun to use in its preparation a sulfuric acid which was made from pyrites containing, as is almost invariably the case, arsenic. Prior to this time it appears that the sulfuric acid used had been that made from sulfur. It was a long chain of evidence, but was complete, for arsenic was found in the beer, in the glucose, in the acid and in the pyrites, and the amount found in the beer corresponded to that in the ingredients used in its manufacture. The quantity was amply sufficient to occasion all the symptoms of poisoning which were noticed. Several points of interest have been brought out in the voluminous discussions which have followed this incident, or tragedy, as it would be better to call it. In the first place, attention has been called to the difficulty of detecting arsenic in beer and similar liquids by methods which had been commonly used. In this way several analysts were led to pronounce beer to be free from arsenic, which was afterwards shown by other methods to contain notable quantities of the poison. It now appears that the test most to be relied on in such cases is that of Reinsch, which consists essentially in boiling the beer, strongly acidified with pure hydrochloric acid, with clean copper foil, and then subliming the black deposit obtained on the copper, if arsenic is present, in a glass tube. The presence of a sublimate of bright octahedral crystals of arsenious oxid is certain evidence of arsenic in the beer. Difficulties in carrying out the ordinary tests for arsenic with many beers, which were examined in large numbers when the public had been aroused to the danger of contaminated beer, led to the discovery of substances added to the beer, which had no legitimate place in brewing, and which bid fair to occasion a much closer supervision of this industry in the future. Attention has been called also to other industries where sulfuric acid is used, and where arsenic which may be present would be carried over into products destined for general consumption. This is especially true in the case of many substances used in pharmacy. It has also been shown that inasmuch as sulfur is always accompanied by small quantities of the rare element selenium, it is not impossible that its compounds, which are very poisonous, may often be present in sufficient quantity to exert a deleterious influence.

THIS subject has been given a somewhat different turn by the work of Sir Lauder Brunton and Dr. Tunnicliffe upon the injurious constituents of distilled liquors. It is now nearly a score

of years since the remarkable experiments of Dujardin-Beaumetz on the toxic action of the different alcohols. He found that the toxic action of pure ethyl alcohol (common alcohol) was in a certain sense *nil*, that is to say, hogs which were kept in a condition of intoxication most of the time for nearly three years, on being allowed to sober up, appeared to be in perfect health, and presented after slaughtering no visible lesions of any organ. This was the case when absolutely pure liquor was used, but when ordinary spirits were fed to hogs they quickly succumbed, showing symptoms and lesions, especially of the liver, similar to those only too familiar in the case of human inebriates. The conclusion, drawn by Dujardin-Beaumetz from a long series of experiments, was that the toxic quality of alcoholic liquors is due chiefly to the presence of higher alcohols, especially amyl alcohol, the principal ingredient of fusel oil, though methyl alcohol and aldehyde may play a subordinate part. Under any circumstances no distilled liquor is safe to use till it has been 'aged' for several years in the wood. Brunton's researches, on the other hand, seem to show that the presence of fusel oil, in such quantities as it usually occurs in potable liquors, is not a menace to public health, but that the greatest danger is from the presence of furfural and other similar aldehydes, which are derived from the husk of the grain under the influence of heat and acids. Furfural is present to a greater or less extent in all whiskies, but is especially abundant in those made by modern processes, where it is sought to obtain as much liquor as possible per bushel of grain. According to this, the superiority of the liquors of 'ye olden time' was due not so much to the fact that they were better 'aged,' but because they originally contained less of the furfural, having been made more carefully. Brunton's physiological experiments were exceedingly interesting, especially in comparing the after effects of intoxication from ordinary spirits with those of spirits from which the furfural had been removed. In the latter case as soon as the animal was sober it appeared to be in a perfectly normal condition, and showed none of the after effects, which in the former case lasted for a considerable time. It is also worthy of note that those substances popularly used as 'bracers' after intoxication generally contain ammonia or some allied compound, which, from a chemical standpoint, is capable of combining with the furfural and neutralizing its effects.

SINCE the comparatively recent condensation of hydrogen to a liquid, much study has been devoted to its physical properties, and especially to the determination of its boiling-point, since this is not far above the absolute zero. The difficulty regarding the former determinations, which gave the boiling point as —238.4° C., is that being obtained by means of a platinum resistance thermometer, they depended upon extrapolation, which might prove faulty at such low temperatures, as has now indeed been shown to be the case. More recently Dewar has made use of a constant-volume gas thermometer, employing for the gas hydrogen from different sources, and also helium, contaminated with only slight traces of neon. The results obtained show that the boiling-point of hydrogen is —252.5°, or 20° above the absolute zero. Investigations as to the temperature of solid hydrogen are now being carried out, and show a still closer approach to the absolute zero. For some years the researches of Gautier in Paris have indicated that hydrogen is a normal constituent of the atmosphere, and the question may now be considered as settled. Not only has Dewar condensed hydrogen directly from the atmosphere, but Gautier has made quantitative determinations of the amount in different localities. In the air of Paris hydrogen does not seem to be an invariable constituent, though methane (marsh gas) is always present and traces of carbon monoxid, while the unsaturated hydrocarbons are generally

absent. In forest air traces of hydrogen were present, and about half as much methane as in the air of Paris. At a mountain station in the Pyrenees at an elevation of 2,785 meters only two volumes of methane per 100,000 were found, but seventeen volumes of hydrogen. At a sea station, 40 kilometers from the coast of Brittany, only traces of methane were found, but nearly two volumes of hydrogen in 10,000, an amount two-thirds as great as that of carbon dioxid. The source and fate of atmospheric hydrogen is a problem which now awaits solution. Liveing and Dewar seem of the opinion that there is a continual accession of hydrogen to the atmosphere from interplanetary space, and Stoney holds that the earth's gravitational attraction is insufficient to retain hydrogen in the atmosphere. Experiments of Gautier show that when certain crystalline rocks are heated with water a considerable quantity of hydrogen is evolved, which might cause a constant accession of the gas to the atmosphere. The problem must be considered for the present unsolved.

PROFESSOR NIPHER, of Washington University, St. Louis, has discovered that the most sensitive photographic plates may be manipulated in open daylight, and perfect pictures may be developed upon them in sunlight instead of in the dark room. The pictures are separately wrapped in black paper in the dark room, and boxed. They may then be separately unwrapped, in the open fields if necessary, and placed in the plate holders. The camera exposure must be very much greater than in the dark room methods. After the exposure, the plate is taken out into the light and placed in the developing solution. Even if direct sunlight falls upon the plate for a moment during these changes, fine pictures may be developed. There is, however, no advantage in unnecessarily exposing the plate. The developing bath may always be in shadow, but beautiful pictures have been developed in direct sunlight. The pictures produced in this way are positives, while those produced in the dark room by ordinary methods are negatives. The positive is the picture ordinarily obtained by printing off from the negative. The shadows show light on the negative and dark on the positive. The positives produced in this way are greatly superior to those produced in the dark room on over-exposed plates, and the exposure time is very much less, but may be very great. Such pictures of a crowded street show the street with perfect clearness, every moving thing being eliminated. In one exposure lasting for several hours, a team which had stood in one position for half an hour showed no trace upon the plate when developed.

EVERY one who has had experience in photography has lost valuable plates by over-exposure. But Professor Nipher shows that all exposures may be successfully developed. Exposures ranging from a snapshot to an over-exposure of about 2,000 may be developed in the dark room as negatives. The fogging in over-exposed plates is an approach to a zero condition, where the plate is blank. For such exposures bromide is freely used, and a few drops of saturated hypo are added. In ordinary dark room work hypo is carefully avoided. But as the zero condition is approached, it is very useful in keeping the plate clear. As soon as the exposure is so great that the plate cannot be controlled in the dark room, it may be developed in the light. Plates a million times over-exposed can be thus developed. The amount of illumination of the plate while being developed depends upon the amount of exposure in the camera. Instead of using the camera, the plate can be exposed in a printing frame, where it takes the place of the sensitive paper. An exposure of two or three minutes, just out of direct sunlight at a south window, may be developed in the same light. The best results are obtained with a hydrochinone developer. Some photographic

plates have given poor results in daylight, and Professor Nipher recommends Cramer's 'crown' plate.

THE new star in Perseus, which has now waned in the sky, and in the memory of most people, is still an object of discussion among astronomers. Our readers will remember Professor Newcomb's recent article on variable stars and the difficulties in the way of accounting for their periodicity. In the extreme case of new stars the difficulty is greatest. The theories of an outburst from the molten interior and of collision might account for the appearance of the star, but do not explain its rapid waning, nor are they in accord with spectroscopic determinations. Professor Seeliger's theory that a dark star passes through a swarm of meteors is the most satisfactory form of hypotheses, but leaves room for the ingenious suggestion, recently made by the great astronomer, M. Janssen, before the Paris Academy of Sciences. He points out that the apparent absence of oxygen from the sun may be due to its existence in some dissociated condition that the spectroscope would not reveal. This condition may be owing to a very high temperature, and when this becomes low enough to allow oxygen to assume its common form, and so to unite with hydrogen, there would ensue, as a result of the combustion, a great increase in heat and light, which would account for the brilliancy of a new star. The rapid decrease in brilliancy which follows would be accounted for by the formation of an atmosphere of vapor, which would serve as a gradually increasing obstacle to radiation from the star. A corollary of M. Janssen's supposition is that our own sun may at any time reach this transition point for oxygen and blaze out into a fury of heat and light that would scorch all life off the face of the earth. It is, however, a pleasant feature of solar catastrophes that astronomical time is measured by millions of years.

ONE of the most interesting total eclipses of the sun, which the present century furnishes, will occur on May 18, 1901. The maximum duration of totality, which will be about six and a half minutes, is rarely surpassed. This will give exceptional opportunity, provided the sky is clear, for work of any kind, photographic or visual. The region of totality is, however, inconveniently remote, and the weather conditions, which usually prevail at the stations which will be occupied, are not of the best. The shadow begins off the east coast of Africa, a short distance to the southwest of Madagascar, sweeps northeasterly over the Indian Ocean, and crosses Central Sumatra, Southern Borneo and New Guinea, and a few smaller islands. To visit the track of the eclipse from New York, therefore, one must journey half way around the earth, and it matters little, so far as distance is concerned, whether one starts east or west. In spite of the distance, observations will be undertaken by a number of American and European astronomers. In this country, the Yerkes, Lick, Columbia, Amherst and Naval Observatories and the Massachusetts Institute of Technology will be represented by skilled observers. Under the auspices of the Royal and Royal Astronomical Societies, English observers will be stationed at Mauritius, and Padang, on the west coast of Sumatra. At Padang the eclipsed sun will be only 21° from the zenith, and the duration of totality about six and a half minutes. At Mauritius, the chances for a clear sky are much greater than at any other station, but the duration of the total phase is only three and a half minutes. On this account, nearly all the American and European observers are planning to visit Sumatra. The observations may have an added value from the fact that the eclipse occurs near the time of minimum sun-spot activity.

THE chief part of the work in this, as in other recent eclipses, will doubtless be photographic. Owing to the enormous advantages which photo-

graphic methods of research give, they should undoubtedly be extensively employed, but it may be hoped that visual observations by skilled observers will not be neglected. There is a tendency in certain directions to regard solar eclipses as of less importance than formerly. This may be due, in part, to the fact that investigations, which in the past could only be carried on at times of total eclipse, can now be studied throughout the year, and, in part, to the very large number of observations which have already been made. Eclipse expeditions, also, are very expensive, and often end in total failure, owing to clouds. Photography has multiplied the results many times in recent years, but for the solution of many problems in solar physics, as complete records as possible for a long time are necessary. In spectroscopic lines it seems hardly possible to obtain too much material for some time to come. Perhaps more of mystery and interest attaches to the corona than to any other feature, and the present eclipse gives an excellent opportunity for several lines of investigation, in addition to photographs showing its structure and extent. An attempt will again be made to investigate the rotations of the corona, by photographs of its spectrum, which must be sufficiently good to show the slight displacement of the lines caused by the motion of rotation. It is to be hoped, also, that further bolometric observations will be made on the heat radiations of the corona, as well as a study of the polarization of the coronal light. Aside from the sun itself, the existence or non-existence of an intra-mercurial planet has not been clearly demonstrated, since investigations in that line up to the present time have not been conclusive. Certainly no amount of time and labor can be regarded too great, which may be necessary to give us as complete a mastery as possible of the problems which relate to our great parent, the sun.

YALE and Princeton, the two most conservative of our larger universities, have recently taken action that will bring their college courses more into harmony with those of other leading institutions, by giving greater opportunity to elect scientific in the place of classical studies. At Yale, Greek and Latin are still required through the freshman year, but later these studies are elective. In the sophomore year five or six courses must be elected from twelve that are offered, making it possible for a student to specialize in science. In the junior and senior years, the chief work of the student may also lie in the sciences, unhampered by restrictions other than that he must take two courses in languages and literature and two courses in philosophy, history and social science. Courses can also be elected, as at Columbia and Pennsylvania, which count as part of the medical course. At Princeton, President Patton has made somewhat similar proposals looking towards offering courses in physiology and human anatomy, so that students may begin their medical education in the senior year. He, at the same time, suggested adding to the electives in the sophomore year. At present Princeton University requires Latin, Greek and the Bible through the freshman and sophomore years, while about one-third of the student's time is occupied with required studies in the junior year.

CORNELL now admits students to its B. A. course without Latin, and Harvard requires no Latin at the University, but still maintains an entrance examination. Columbia requires Latin in the freshman year, but has recently made it possible for a student to enter without Latin, though he cannot graduate until he has studied this language. The great universities of the Middle and Western States have in most cases established three degrees—A. B. for those who pass entrance examinations in Latin and Greek and study these languages to a greater or less degree in their college course; B. Ph. for those

who do not study Greek, and B. S. for those who study neither Latin nor Greek. It has resulted that only a small proportion of students has taken the A. B. degree, yet the other degrees referred to have no definite and well-established meaning. The bachelor of science degree, for example, does not mean that a student has had a scientific education, but simply that he has not studied Latin and Greek. Under these circumstances it appears that the Universities of Michigan and Minnesota have during the past month taken a forward step in abolishing all college degrees except the A. B., giving this for all courses of liberal studies. It is obvious that the A. B. no longer means a classical education when both in England and the United States its only condition is 'small Latin' in the preparatory school. Scientific students might like to see a degree established that definitely signifies a scientific education —as the B. Sc. of the University of London. The authorities of Columbia University recently considered the desirability of offering such a degree, but it was thought impossible to give the B. S. a definite signification.

DR. GEORGE DAVIDSON, professor of geography in the University of California, has been elected a correspondent of the Paris Academy of Sciences.—St. Andrews University has conferred its LL. D. on Mr. Alexander Agassiz, of Harvard University, and Aberdeen University has conferred the same honor on Professor Rudolf Virchow, of Berlin.—Mr. J. J. H. Teall, F. R. S., has been appointed director-general of the Geological Survey of Great Britain and Ireland, in succession to Sir Archibald Geikie, who retired on February 28. Sir Archibald has been in the service of the Survey for forty-six years and has reached the age limit.—Prof. S. M. Babcock, of the University of Wisconsin, inventor of the Babcock milk test, was, on March 27, presented with a medal, voted him by the State for giving his invention free to the world. Exercises were held in the Assembly Chamber of the Capitol in the presence of both Houses of the Legislature, the university faculty and regents and many prominent citizens of the State. Governor Lafollete presided, and addresses were made by him, by ex-Governor W. D. Hoard and others.—A committee has been formed to erect at Heidelberg a monument in memory of three of its great scientific men, Bunsen, Kirchoff and von Helmholtz.—A memorial marble bust of Robert Brown, the eminent botanist, formerly a student at Aberdeen, presented to the university by Miss Hope Paton, has been unveiled in the picture gallery of Marischal College.—Three expert geologists from the United States Geological Survey (Dr. C. Willard Hayes, Mr. T. Wayland Vaughan and Mr. A. C. Spencer) have been detailed to make a geologic and mineral reconnaissance of the Island of Cuba.—The Coast and Geodetic Survey steamships, Pathfinder and McArthur, at San Francisco, and the Patterson and Gedney, at Seattle, are now fitting up, under orders to proceed to Alaska to survey important passages among the islands along the Alaskan cost.—Dr. Patrick Geddes, who was responsible for the formation of the International Association for the Advancement of Science, Arts and Education, and the holding of an International Assembly at the Paris Exposition, last year, proposes a similar assembly, in connection with the exposition and congresses to be held at Glasgow this year. —The second Latin-American Scientific Congress opened its two-weeks' session at Montevideo on March 20, with over 200 delegates in attendance. Dr. Robert Wernicke, professor of pathology in the University of Buenos Aires, Argentine Republic, was elected president of the Congress.—In order to make the free distribution of seeds by the United States Department of Agriculture as useful as possible, Secretary Wilson has secured authority to send out young trees as well as seeds.

THE death of Dr. William Jay Youmans is a personal loss not only to his many friends, but also to the thousands of those who knew him only as editor of this journal. Youmans was born near Saratoga on October 14, 1838, and the boyhood on his father's farm gave him the training which has so often led to the elevation of public and professional life in this country. He was descended, as his name witnesses, from the British Yeomanry, and the sterling stock that settled in New England was typified in his person and character. He loved his home in the country, and had purchased a farm nearby, to which it was his intention to retire to pass the years of rest that he had so well earned. After leaving the home farm at the age of seventeen, Youmans studied under his brother, the late Dr. E. L. Youmans, and later at Yale, Columbia and New York Universities, and in London under Huxley. He practised medicine for several years in Minnesota, and in 1872 joined his brother in New York to establish the POPULAR SCIENCE MONTHLY. For twenty-eight years his life was devoted to this journal, first in association with his brother—who was seventeen years the older, and died in 1887—and afterwards as editor-in-chief. The two brothers not only edited the journal, but as advisers of the house of Appleton, gave them their high standing as publishers of scientific books in the renaissance of science based on the doctrine of evolution. The teachings of Spencer, Darwin and other great leaders were for them a religion to which their lives were consecrated. Their influence through this journal and other publications of the Appletons was great and permanent. Youmans died at Mount Vernon on April 10 from typhoid fever, after a ten days' illness. His life was devoted with rare singleness of purpose to the diffusion of science; it was a privilege to know him; he was gentle, kind and noble.